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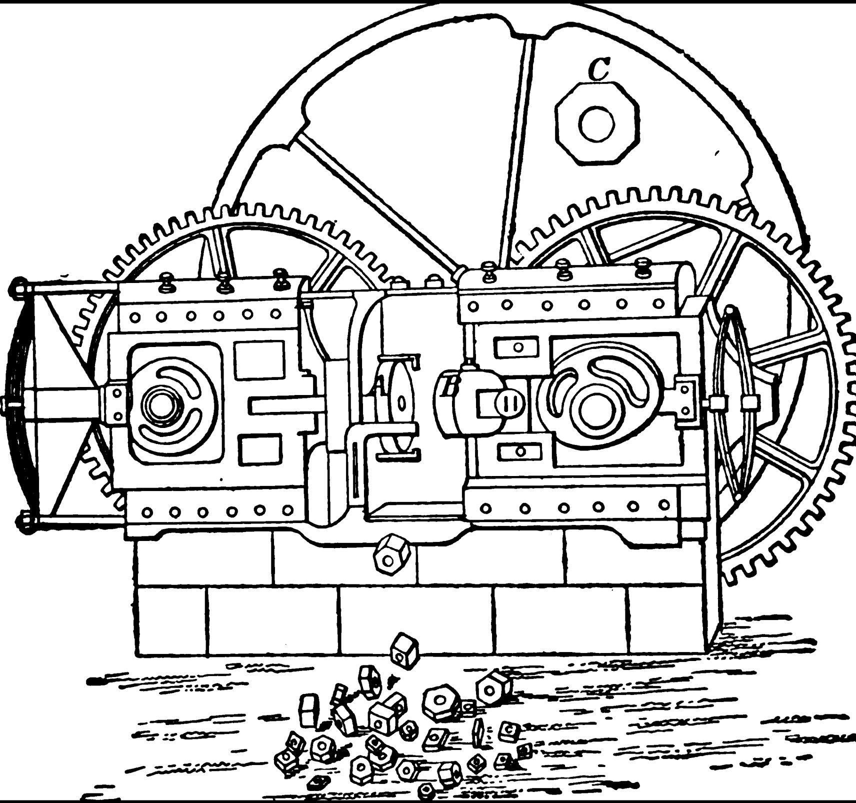

British Manufacturing Industries : Guns, nails, locks, wood ...

G. Phillips Bevan

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BRITISH
MANUFACTURING INDUSTRIES.

BRITISH
MANUFACTURING INDUSTRIES.

EDITED BY
G. PHILLIPS BEVAN, F.G.S.

III.

GUNS, NAILS, LOCKS, WOOD SCREWS, RAILWAY BOLTS AND SPIKES, BUTTONS, PINS, NEEDLES, SADDLERY, AND ELECTROPLATE.

By the late W. C. Aitken (Birmingham).

PENS AND PAPIER MÂCHÉ, AMMUNITION, PERCUSSION CAPS AND CARTRIDGES, ANCHORS AND CHAIN CABLES.

By G. Lindsey (Birmingham).

SECOND EDITION.

LONDON:
EDWARD STANFORD, 55, CHARING CROSS.

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PREFACE.

THE object of this series is to bring into one focus the leading features and present position of the most important industries of the kingdom, so as to enable the general reader to comprehend the enormous development that has taken place within the last twenty or thirty years. It is evident that the great increase in education throughout the country has tended largely to foster a simultaneous interest in technical knowledge, as evinced by the spread of Art and Science Schools, Trade Museums, International Exhibitions, &c.; and this fact is borne out by a perusal of the daily papers, in which the prominence given to every improvement in trade or machinery attests the desire of the reading public to know more about these matters. Here, however, the difficulty commences, for the only means of acquiring this information are from handbooks to the various manufactures (which are usually too minute in detail for general instruction), from trade journals and the reports of scientific societies; and to obtain and systematize these scattered details is a labour and a tax upon time and patience which comparatively few persons care to surmount. In these volumes all these facts are gathered together and presented in as readable a form as is compatible with accuracy and a freedom from superficiality; and though they do not lay claim to being a technical guide to each industry, the names of the contributors are a sufficient guarantee that they are a reliable and standard work of reference. Great stress is laid on the progressive developments of the manufactures, and the various applications to them of the collateral arts and sciences; the history of each is truly given, while present processes and recent inventions are succinctly described.

BRITISH MANUFACTURING INDUSTRIES.

GUNS.

BY THE LATE W C. AITKEN (Birmingham).

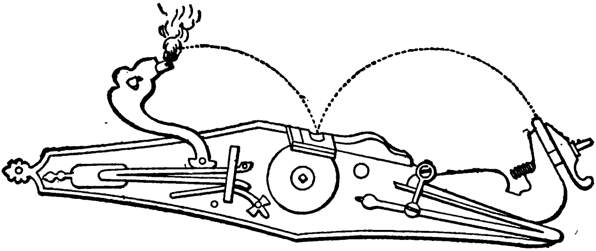
THE manufacture of fire-arms had its origin in the discovery of saltpetre, charcoal, and sulphur, forming an explosive compound, now known as gunpowder. The Chinese appear to have been aware of its properties for upwards of two thousand years, and employed it or a similar compound for purposes useful and ornamental: in the former, for the removal of natural obstructions, as the blasting of rocks; the latter, for the making of fireworks. Stanton, in his account of his embassy to that country, states that its force had not been directed through strong metallic tubes as in Europe, but Captain Parish (who formed one of the suite of Lord Macartney) discovered in the Great Wall, embrasures or perforations, similar to those in European buildings, and he came to the conclusion that the Chinese used "jingulls" or wall guns, or some kind of fire-arms this suggestion is confirmed by a Spanish writer, on the authority of a monk who had travelled in

China, and gives even the name of the inventor of firearms. A letter written to the King of Spain by a captain in his service also says, that he saw a very old species of cannon in the arsenals of China. Nitre, the chief element in gunpowder, being a natural product alike of China and India, its properties would no doubt be investigated by the philosophers of these countries at a very early date. A Hindu poet in 1200 speaks of the "loud reports, the noise of projectiles," as heard at a mile's distance; and in 1368 Mohammund Shah Bahmiane captured in India 300 gun carriages, while artillery of old date was found by the Portuguese in India in 1498. The evidence is all in favour of gunpowder, or some other explosive, having been known in the East before it was used by the nations of Europe. Roger Bacon (born in 1214), in his *Opus Magus*, tells us how with an instrument as large as the human thumb, by the violence of the salt called saltpetre, so terrible a noise is made by so slight a thing as a bit of parchment, that it is thought to exceed loud thunder, and the flash is stronger than the brightest lightning. Schwartz, a monk of Cologne, is a rival claimant, though the date at once settles the priority of the invention in favour of Bacon. Englishmen, thirteen years after its discovery, made use of it in tubular formed implements from which to impel missiles; Edward III. used cannon in his wars with the Scots in 1327, and Grose, the antiquary, quotes a Father Daniel, who says that the French first employed ordnance in 1338.

During the next two centuries we have several incidents mentioned of fire-arms, under various names; even Spain, which was then (1555) in the zenith of its glory and prosperity, using muskets, though very heavy, supported by a stave shod with iron to aid in taking aim. Italy was not slow to recognize the use of portable fire-arms, and at Pistoia in 1544 the lightest "small arm" up to that period was produced, viz. the pistol, which name was derived from the town where it was first made.

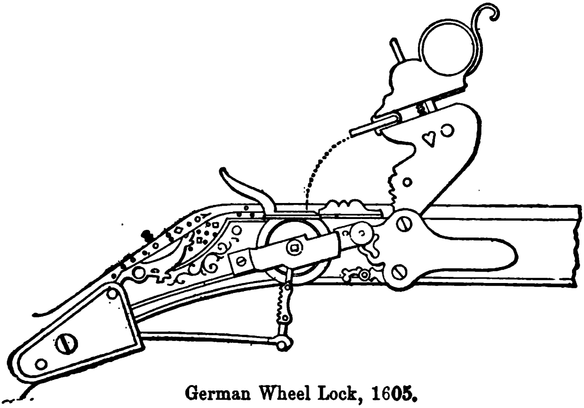
The fire-arm of 1874, the united result of applied science and mechanism, whether produced by hand labour, or by ingenious automatic machines, presents a very great contrast to the roughly made "cannon" or "small arm" of a by-gone period. It is both instructing and entertaining to trace the early recognition of breech loading and the revolving arm in collections, such as the Arsenal at Venice, the Museums of Florence and Dresden, the "Artillerie" at Paris, in our own Museums in this country, and in private collections, such as the "Meyrick." The revolving arm of Colt, and the whole family of modern breech loaders, have their prototypes in these examples; and indeed the principle, somewhat crudely developed, was recognizable in the submerged guns fished up from the wreck of the 'Mary Rose,' sunk in the reign of Henry VIII. It is also set forth on a patent taken out 210 years ago by one Abraham Hill, "which states that the breech rises upon a hinge by a motion under it, is let down again and bolted fast by one and the same motion; and in another gun or pistol, with a hole at the upper end of the breech to receive the charge, the hole is opened or stopped by a piece of iron or steel, that lies along the side of the piece, movable by a ready and easy motion.*

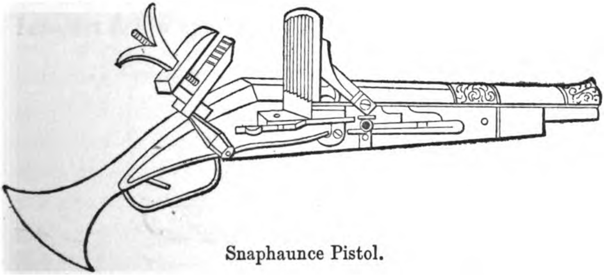
The earliest portable fire-arm was a rudely formed tube of iron, tied or fastened to a straight piece of wood, the contents being discharged by a lighted match applied to priming powder, placed round the touchhole. A pan was next added under the touchhole, placed at the side of the tube, so as to retain the priming powder better; and for the application of the match by hand, a simple lock was substituted, in which a cock slit to hold the match was kept back by a spring, so that on pulling the trigger, the match dropped down and ignited the powder in the pan. Italy and Germany claim the next improvement, viz. the "wheel" lock, which was wound up with a key, its mechanism being a steel wheel, the outer circumference of which was rough or furrowed, and having a chain attached to the axis by which a spring was wound up (as in an ordinary spring clock or watch), held by a ratchet. The latter,



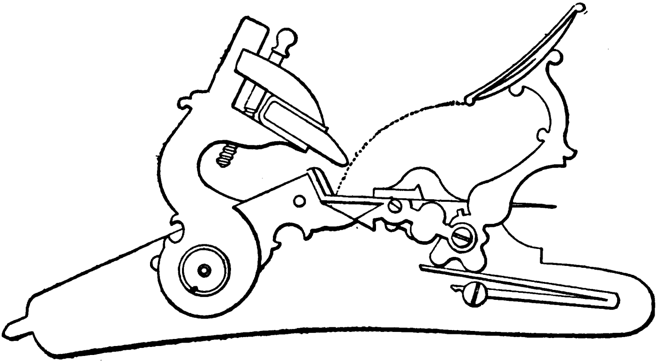
Wheel Lock, 1590.

relieved by the operation of the trigger, caused the steel to revolve against a piece of pyrites held in a "cock" head, which dropped against it in its revolution, produced a stream of sparks, and ignited the priming powder in the pan. The Snaphaunce lock was due to the Dutch, and was the type of the flint lock, flint

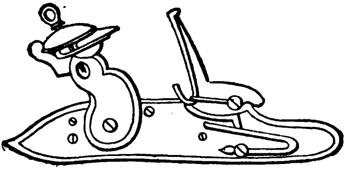

German Wheel Lock, 1605.


Snaphaunce Pistol.

being substituted for pyrites as the spark-producing material. Its construction was a cock carrying the flint, a hinged furrowed piece of steel which covered the pan, and a trigger operating on springs which released the cock bearing the flint. The flint locks of the old "Brown Bess" of the British army, altered into percussion only in 1842, or the fowling pieces used in

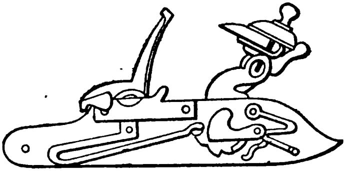


Snaphaunce.



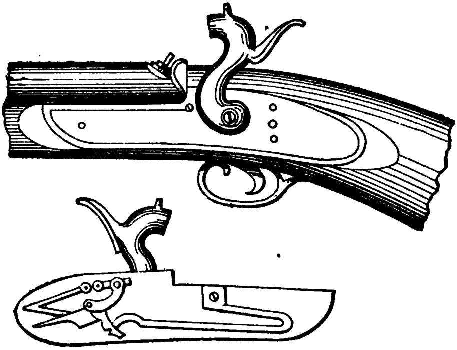
Flint Lock used previous to introduction of percussion principle.—1.

England for so many years prior to 1807, were simply improvements on the construction of the "Snaphaunce" lock.



Flint Lock used previous to introduction of percussion principle.—2.

In 1807 a new principle was applied to the discharge of fire-arms, invented by Forsyth, viz. that of percussion, in which fulminating powder was substituted for the flint, the cock which bore it being converted into a hammer. In its latest and most perfect development, the percussion lock may be described as follows. The

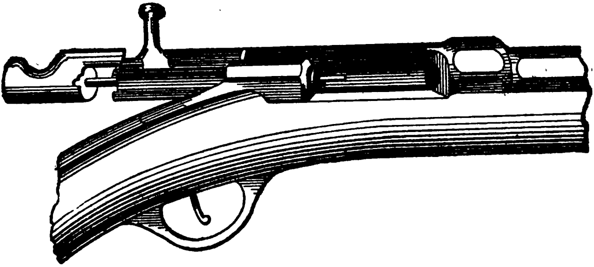


Percussion principle illustrated.

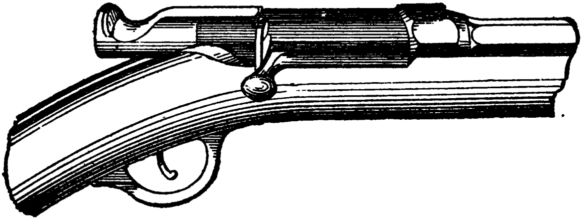
hammer was released by springs, and fell or was impelled upon a perforated steel nipple, on which was placed a small copper cap with some fulminating powder in its interior; the blow of the hammer exploded the fulminate, the fire or spark from which descended down the perforation in the nipple, communicated with the powder in the barrel of the gun, and discharged its contents. The percussion principle deservedly held its place for half a century, or until the recognition of the breech-loading system, when the cartridge containing within itself the means of its own ignition, may be said to have entirely displaced it.

When the superiority of the needle gun of Prussia, in 1864, became apparent, and experiments proved that the danger arising from the use of cartridges containing their own means of discharge was a myth, the old system of construction of fire-arms may be said to have come to an end. Stock, lock, and barrel have been changed, and but little now remains of the old flint or percussion lock, all the features of which have given place to details more useful, but not so externally attractive.

The recognition of the breech-loading principle has been followed up by nearly 600 inventors, prominent among whom are Snyder, Richards, Albini, Remington, Lancaster, and Martini, &c., from the needle gun of Prussia to the chassepot of France, and thence again down to the latest improvements in breech loading. Two ideas seem to have occupied the inventive mind. First, the opening of the breech by pulling back a bolt, which, after introducing the cartridge, is again pushed forward, the handle of the bolt being turned down to the right, and held in its socket like an ordinary domestic barrel bolt, though in the bolt of the gun there is an arrangement by which the cartridge can be discharged and its empty case withdrawn. Secondly, as in the "Snyder," the block which closes the breech opens to the right or to the left, is attached to the breech piece, and is hinged, turning freely. The outer or movable breech-closing piece of

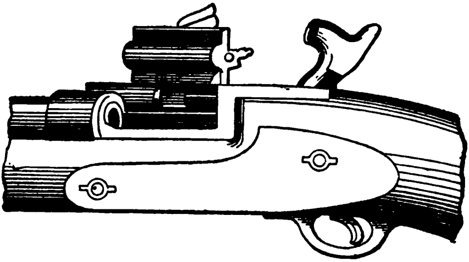


Bolt Gun—Breech open.

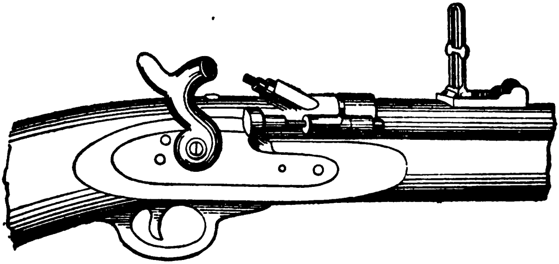


Bolt Gun—Breech closed.

metal is held fast by a spring bolt, on the exterior of which will be observed a projection or nipple; this contains a spindle held in position by a small spiral spring, which, on being struck by the cock or hammer (on its release by the trigger), is driven against the end of the cartridge containing the fulminate, and discharges the piece. The fire communication is central to the charge, and provision is made for the with-



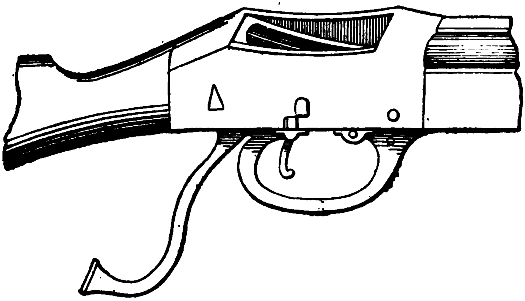
Snyder Breech-loader—Breech open.



Snyder Breech-loader—Breech closed.

drawal of the empty cartridge case by the opening of the breech for the introduction of a charged one instead. As the "percussion" principle took the place of the flint in 1842, so the breech loader replaced that of percussion, and the Enfield percussion rifles were converted, by simply cutting off a portion of the breech end of the old barrel and adding the new breech block thereto.

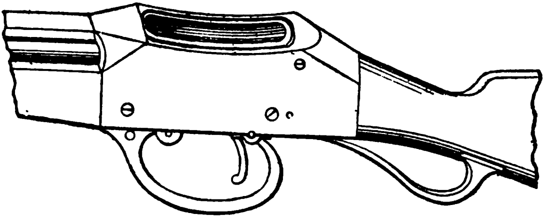
Recently, however, authority in high places has declared in favour of the Henri-Martini system of breech loading, which is neither a bolt, nor a movable block opening to right or left, but consists in an oblong mortised iron box with a movable ringed lid operated upon by a lever, which might under the old flint system have been taken for the "guard." The cartridge is introduced by moving the lever, which depresses the lid or cover of the breech space, and permits of the introduction of the cartridge; the lever is then moved



Henri-Martini Breech-loading Rifle—Breech open.

back, and by so doing raises the lid of the breech cover. Provision is made for the discharge of the cartridge, by the propulsion of a projecting spindle; and after firing, the spent cartridge case is withdrawn by moving the lever, and the soldier, by tilting the "arm" to the right, drops it out.

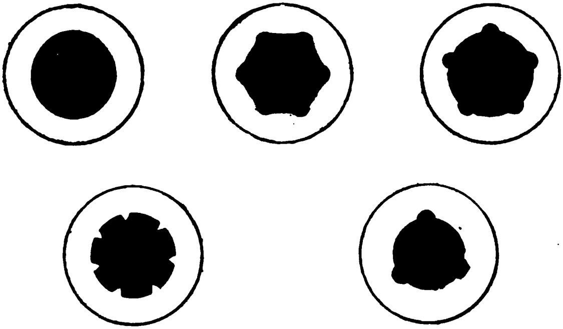
The chief points in the construction of guns, as regards locks or means of firing, having been glanced at, I will now come to the barrels, and more particularly the rifling of them, in order to direct the bullet with certainty. Zollner, of Vienna, made one of the earliest examples in 1620, and Koster, of Nuremberg, gave a spiral or winded direction to the grooves, in order to make the bullet spin on its own centre, while in England, Arnold Rouspen, a foreigner, in 1635, seems to have been the first "to rifle, cut out, or screw barrels as wyde or as close, or as deep or as shallow, as shall be required, with great ease." The grooves in rifle barrels vary in number from three to five or even seven. The Enfield rifle has three, the Whitworth



Henri-Martini Breech-loading Rifle—Breech closed.

seven, but the different form of the cutter used converts what are practically grooves in other rifle barrels into convex threads, traversing the interior. The "Lancaster" rifle is at the mouth of the barrel apparently an oval "bore," but in the interior of the barrel the oval is "winded," with the intention of giving the spinning motion to the bullet.

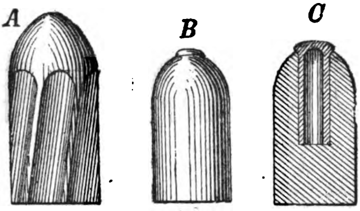
To suit the varieties of rifling, the bullets used now are no longer spherical, but elongated, nor are they cast in moulds, but made by compression with dies from coils of lead wire. The Whitworth bullet was made to fit the rifling of the barrel, but experience has proved this to be unnecessary, for the bullet is compressed by the explosion of the powder, so as to fit every groove. The "Express" bullet is in length twice its diameter, while lightness, which is an advantage for ordinary range and ensures the spinning of the



Varieties of Rifling.

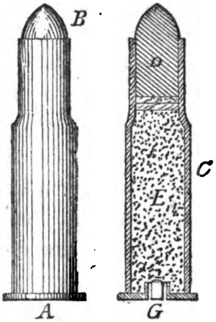
bullet, is secured, by its being made hollow and by the insertion of a solid ended copper tube, which may be filled with fulminate, and converted into a miniature shell, causing the bullet, on its meeting with an obstruction, to expand, and inflict a most dangerous injury.

Modern requirements associate in the breech loader the bullet and ammunition in the form of a cartridge, which within the last ten years may be said to have created a new industry. The metal case was formerly made of thin paper, or as more recently in the "Boxer," of thin brass, and rolled up into a tube, but is now produced from flat discs of metal, converted by means of presses, aided by punches and bolsters, into seamless tubes. In this labour and in filling the cartridges upwards of 1500 females are engaged, and if to these are added 660, engaged in the manufacture of the percussion caps which are introduced into the cartridge, the aggregate number of hands employed amount to 2100 in this auxiliary to the gun trade.



A. Whitworth Bullet. B. Express Bullet. C. Express Bullet in section, showing tube for fulminate to convert into a Shell.

Vast establishments are occupied in the production of cartridges alone, and these have increased the consumption of the composite metal brass, requiring the labours of large numbers of metal rollers and others, employed in making the tools by which the cartridges are produced.

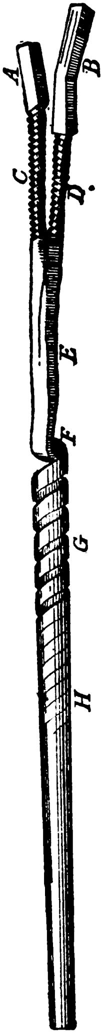


A. Cartridge case.
B. The Ball.
C. Cartridge in section.
D. Ball in do.
E. Powder.
G. Percussion Cap struck by piston of breech-loaders to explode cartridge.

I shall now briefly describe the manufacture of fire-arms; gun making, as a trade and as a manufacture, being very different things. The country gunsmith usually buys the barrel and mountings for the gun from the large manufacturer, the barrel being nearly finished, all except the last "bore." If for a rifle, it is "threaded" or rifled. He makes the mountings, such as butt plates, guard and lock plates, for the lock, the springs, &c., and does all the fitting together of the iron work to the stock, and polishes, "browns," or "blues," the metal work. The country gunmaker can produce any part of a gun, but it will be evident that, had gun making been conducted on similar principles, England could never have achieved the position that she has, as the most successful gun manufacturing country in the world.

In its great seat, Birmingham, advantage was taken of the division of labour, and previous to the introduction of automatic machinery, the production of a gun was distributed over fifty individuals. There were welders of barrels, "borers" of the interior, "grinders" of the exterior, workmen to "file" and to "breech," make "ribs" and forge, or stamp the breech, forgers of various parts of the mountings of a gun, i. e. of butt plates, guard, trigger, and spring casters, when the mountings were cast, as in brass or in iron, thereafter to be made malleable by annealing in close iron boxes with ground hæmatite iron ore. There were special filers for these, while ramrod forging formed a speciality, and there were also bayonet forgers; the two last named had each separate grinders, polishers, machiners, filers, and hardeners. There were band forgers and stampers, machiners and filers, while the "screw pins" which entered into the fitting together of the lock also formed a speciality. The "sights" by which aim is taken involved also a division of labour; and there were trigger "boxers," filers of "lumps" and "break-offs," who prepared only the breech end of the barrel; "percussioners, who finished only the nipple seat; "jiggers," who fitted the nipple and adjusted the hammer which struck the cap on the nipple; "stockers," who "let in the barrels and locks to the stock; "screwers," who put in the screws and completed what was left undone by the stocker; "strippers," who prepared the gun for rifling and proofing; adjusters of the sight; "smoothers," who prepared the barrels for colouring or browning"; finishers, who distributed the various parts, and when they were returned from the several workmen, put the guns together and adjusted them. Besides "makers off," who gave the stocks their final finish, there were engravers, who executed the decorative enrichments; and lock "freers," who examined, and made the lock sweet and free in its action.

The process of manufacture will now be described, previous to the introduction of the gun-making machinery. In common guns, the barrel was forged from iron called "skelp," which was heated, turned up into a tube and welded at the junction of the two edges by the hammer, or by passing it through grooved rolls. The larger "bore" of the old guns permitted the use of a mandril in the operation of welding, while barrels of a middle and those of a superior quality were made, by winding a ribbon or narrow strip of iron round a mandril in a spiral direction, welding the edges of the strip together. Another quality of very superior excellence was produced, by taking a bar of steel and another of iron formed out of horseshoe nails, and welding them together. The bar produced was twisted, drawn into thin strips and again welded, and the barrel thus made was called a "Damascus twist" barrel. In another variety, very thin ribbons of steel were welded into one bar, while horseshoe nails formed another. Both bars were twisted, or welded into a single one, from which a strip was made, to be wound round a mandril as already described, and welded at the junction of the twists.



A. Bar formed from horse-nails welded together.
B. Ditto ditto ribbons of steel ditto.
C. Horse-nail bar twisted.
D. Steel ribbon-bar twisted.
E. Junction of the two bars.
F. Welded together.
G. As wound round mandril.
H. Ribbon welded.

This imparted the twisted appearance observable on the barrels of best guns in the application of the acid used in "browning." The roughly forged barrel was then passed into the hands of the "borer," who, with his long-shanked square bits, placed the barrel on his bench, and by manual labour formerly, but by "power" now, bored it out, the barrel in the process of boring being clipped by a clamp on which was a projecting pin—while the bench in its external horizontal surface had also pins placed perpendicularly at certain distances. A bent lever, the fulcrum of which is gained from the pins on the frame, pressed upon and forced the barrel against the boring bits; and during the operation, in order to keep the band cool, a supply of water trickled down upon it. The final boring of the barrel, after a succession of "bits" had been passed through it, was facilitated by a boxwood splint applied on the sides of the bit, which reduced the cut, and rendered the polishing of the bore comparatively easy. The barrels, admitting that they were perfect, were then sent to the grinder, who on large stones set in motion by power, ground the surface of the barrel with an accuracy and truth which long practice only could give. In some manufactories, the barrels were turned in a lathe by means of a travelling slide rest, but after being turned, they were still subjected to the grinding process. Then followed the fitting-in of the breech pieces, which required the screwing of the interior of the butt end of the barrels. The setting of the barrel was accomplished with unerring certainty by simply "viewing," or looking down the interior, applying a judicious tap with a wooden mallet.

The other portions of the gun, as butt-plate, guard, triggers, springs, &c., were originally produced by hand forging, but greater accuracy and diminished labour in removing excess of metal have resulted from the use of the stamp and die, in which is sunk the intaglio representation of the gun mount. The hammer of the stamp carries a counterpart of the die, on which the heated iron is laid; the hammer descends, and a succession of blows produce a counterpart of the cut. The filers and finishers supplied with the iron blanks proceed to file up, fit, and otherwise finish the several parts, while those which could not be finished with the file or turning tool are worked by "grinders," or revolving tools, to which motion is given by the lathe, or drill-bore (chiefly the former). Screws are made, by which the several parts of the lock are articulated or placed in proper connection with each other and fitted together, though yet unfinished, while the lock, barrel, and other parts are conveyed to the "stocker," who fits them on the stock, and makes the necessary preparation for the reception of the ramrod. The fitting of metal parts to the stock having been accomplished, the gun is taken to pieces and distributed among the various workmen who have produced the several parts; the sights are attached to the barrels, which have previously been proved at the proof-house, and the latter are then polished by friction with emery sticks and ore and sent to the "browner," or colourer, who, with his mixture of acid stain, can produce on inferior iron the appearance of "twists" and veins superficially, which gives such intrinsic value to the best barrels.

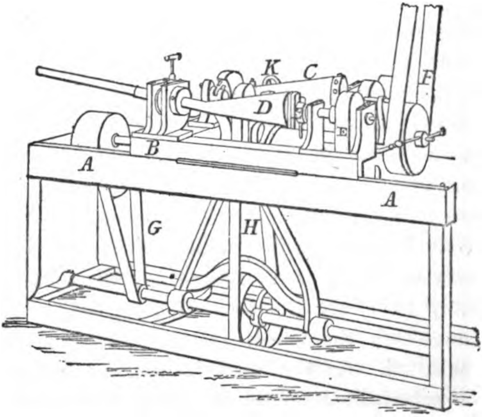
Another system of gun making has been introduced within the last eighteen years, in which, so far as the formation of the several separate parts of a gun are concerned, human labour is almost confined to the superintendence of the machines by which the several parts are produced, and to that which no machinery will ever accomplish, viz. the connection and fitting together of the several portions made by the machinery. It must be evident also, where numbers of articles are required for a given purpose, in which taste forms no element, and practical usefulness is the only end aimed at, that, one example of a satisfactory kind having been made, the power of inventing tools or machines to reproduce its parts is not beyond the means of accomplishment; and that this can be done, and that every part can be made to be "interchangeable," was demonstrated by the Americans, upwards of a quarter of a century ago, at the Springfield Armoury, Massachusetts, U.S.

This system of gun manufacture, first reported upon by Sir Joseph Whitworth, when sent as English Commissioner to the New York Exhibition of 1853, resulted in a Commission being appointed, the members of which, military men or others immediately connected with the Board of Ordnance, reported on the efficiency and speed in productive power of the Springfield machines. The Enfield gun manufactory was commenced and fitted up with American machines, and private local enterprise originated almost at the same time the small-arms factory at Small Heath, near Birmingham, where was adopted the same class of machines, which have since been materially improved upon. At Enfield and Small Heath, stamps moved by steam, produce with unerring certainty from "blanks" of iron of suitable size butt, lock, plates, and portions of the lock, breech pieces, shoes, barrel-holder hoops, nose-caps for stocks, sights, guards, trigger pieces, bayonet blades, and sockets. Presses fitted up with cutting-out tools, punch out, trim, and relieve the stampings from the superfluous metal, or "fins," left after stamping. Forging machines of rapid action draw out the "swivels," and afterwards bend into form, or forge the portions of the ramrod which are of unequal diameter, while steam hammers produce the heavy perforated breech pieces of the Martini and other breech loaders.

The finish of the various portions which make up a gun or rifle is effected by machines, which carry drills, bits, grinders (or wheel cutters), all made to gauge and tested thereby, and which drill or open out the internal parts of the portion to fit on. These are placed on mandrils, &c., corresponding to their internal configuration, and which, firmly held there, have their external contour delineated by machines fitted with tools, which operate as a planing machine horizontally, as a slide rest perpendicularly, or as rapidly revolving "grinders" (i. e. toothed steel wheels); the amount of "cut" is determined by a "tracer," which follows the contour of the model of the part desired to be copied and reproduced. The whole system employed is that invented by James Watt, and applied in his sculpturing machine nearly sixty-eight years ago (still to be seen dust-covered in his garret workshop at Heathfield, Handsworth), and also in the copying machines of M. Collas, Cheverton Bates, and Jordan's wood-carving machinery. The "tracer" defines the tool cuts, the depth of the cut is determined by the model traced, but all the machines, however numerous, whether operating on wood or metal, are simply copying, though copying with undeviating accuracy even to the 3000th part of an inch. No hand labour could accomplish such accuracy or such unvarying uniformity, for a thousand portions produced by the machine are the same, and are "interchangeable."

There are machines to produce and all but finish every part, though the irregular forms of some show that their internal and external contours necessitate the employment of many different machines. In some of these a change in the form of tool or cutter and the model to be copied will suffice, but in the production of an Enfield rifle, the processes gone through exceed 700, and this will explain the necessity for the variety and number of the machines used.

In no parts of the machine-process of gun making is the advantage more strikingly apparent, than in the production of the "stock" of the gun, the fitting in of the lock, and the perforation of the wood through which the connecting screws pass, and in which the ramrod lodges. A gun stock made by hand is a slow, tedious, and expensive process. By machinery it is just the opposite, and is produced with all its peculiarities of varying thicknesses and sections in three minutes. It is turned in a lathe, two changes of position only being required; by the one the butt is produced, up to where the lock fits; by the other, the part on which the barrel rests, and into which the lock is fitted. As the stock-turning lathe embraces all the principles involved in gun making by machinery, a cut is introduced with the model and the stock in course of production, *in situ.* The "blank" of wood out of which the stock is made is received from the stores in the form of the future stock, but very imperfectly. It is laid on a machine held by "guides" in a position to ensure the angle of the butt-end placed against the shoulder being correct; if not, the excess of wood is removed with a circular saw, and it is then laid flat against a proper template, into which four movable points are fitted. A blow with a hammer drives these points into the end of the stock, leaving four holes, and the blank is then placed against four spikes attached to a face-plate which revolves with the spindle. The spikes fit into the holes already perforated, and the wood which supports the barrel passes through a collar and is held at the part a little beyond where the lock fixes; the butt end is now "centered," and an iron model of the intended stock attached at a little distance from the "blank." The



Machine used for turning gun-stocks.

A A. Bed of machine.

B. Collar through which barrel end of stock is passed—which revolves.

C. The cast-iron model of stock.

D. The wood to produce the stock.

E. The revolving head carrying face-plate against which butt end is fixed.

F. The belt, which gives motion to the lathe.

G and H. Belts giving motion to cutting tools, and connecting these with the wheel-tracer K (which follows or passes over every part of the cast-iron model C).

"tracer" of the iron model is a revolving wheel of metal, which is forced by a weight to press against the model, and to follow its varied contour by means of a counterpoise weight suspended to the tracer. The cutting tools, twelve in number, are fitted to a block of metal arranged in a series of four; the first four get rid of the superfluous timber (these are gouge-formed); the second produces a nearer approximation to the correct shape, while the last four chisels smooth the stock, to enable the final finish to be given with glass-paper by hand. The rationale of the operation of the stock-turning lathe is, that the tracing wheel follows the contour of the model and operates on the cutter block, and thus the former wood blank is converted into the finished stock with all its varying sections, thicknesses, and peculiarities of outline.

The barrels, which are now formed entirely out of steel, not welded in ribbons as described before, but drilled through out of the solid, are bored with rimers to the size, and "rifled" by skilfully constructed machines. They are then turned in their entire length by slide rests, and the polishing of the barrel is also done by machinery. Accuracy in every part of the gun is ensured, by subjecting it to gauges of the most unerring truthfulness; the value of this accuracy is most important, as a portion of the arm when broken in service can be replaced from the stores of interchangeable duplicates, by the simple removal of the broken part and the substitution of a perfect piece. The putting together may be said to be the only detail which requires skilled labour. The arm is taken to pieces, which are distributed, polished, and sent to "browner" or "bluer"; the stock is glass-papered, oiled, and varnished, after which the parts are finally put together or "set up." They are then subjected to the examination of an authorized inspector, or "viewer," appointed by the Government or purchaser for whom the arms have been produced.

The distinction between the production of fire-arms by the old method of hand labour and the new system of "machining" or automatic machinery having been described, the difference between the two methods will be readily understood. The former is liable to the errors of all hand labour; in the latter, all things being properly attended to, the result must be absolute accuracy. Prejudices against the system are rapidly being dispelled, for the makers are introducing machines to effect more readily certain portions of the work, and the workmen do not now object to use these appliances.

Viewed as an industry, the manufacture of fire or small arms occupies no mean place among those of England, as the following brief summary will show. Of artisans employed: of males there are 12,017, and of females 306, of which about three-fifths are at work in and about Birmingham alone. Their earnings vary, but bear a relation to the ability and responsibility with which each discharged their several special requirements, and all earn higher wages than those of France, where, previous to the last wars, the average varied from 14*s.* 3*d.* to 16*s.* 7*d.* per week. In Belgium, at Liege, the centre of the gun trade, the average was 12*s.* per week, but this included the earnings of women and children, and the average of men was 20*s.* 10*d.* per week, exceptional cases realizing higher wages.

It was probably owing to the knowledge, that in no town in England were to be found so many mechanics capable of executing new work as in Birmingham, that gun making became one of the great British industries.

In the reign of William III., the ability of the workmen, in adapting themselves to the production of new special objects in metal, was the subject of a letter from the War Department to Sir Richard Newdigate, at Arbury, near Warwick, directing his attention to two Snaphaunce muskets of two different patterns (sent by the Tamworth carrier), and asking him to cause them to be shown to "ye Birmingham workemen," requesting him to ascertain their ability to make, and if they could undertake the production of similar articles, and to state their lowest price for a complete "musquet" ready fixed; or for a barrel, or a lock, "or together as they will make them." A reply was sent, and three years after a trial order was received, in which we recognize, for the first time, the safeguard element of a "proof-house for barrels," an official "viewer," and an official mark after "viewing" struck on every portion of the "arm." The price of the "musquets" was 17*s.* each, and their carriage to London, at the rate of 3*s.* per hundredweight. They were to be sent in quantities of 100, and cash paid a week after delivery. Up to the period when the above order was given, all the guns for the English army were made in and imported from Germany. The manufacture of military fire-arms in Birmingham continued brisk up to the peace of 1714. The production of sporting guns was commenced there in 1793. In 1803 the demand for military guns again became urgent, and exceeded the Birmingham power of production, so that supplies were again purchased from Germany. The energy of the manufacturers caused artisans engaged in other metal trades to flock to their workshops, and materially to increase the supply of guns. Statistics show that from March 31st, 1804, to September, 1815, they produced of muskets, rifles, carabines, and pistols 1,743,382, and for the Board of Ordnance during the three years from August 14, 1814, to August, 1817, of muskets of a new pattern 84,507, or a total of 2,673,366. In addition to these, within the period from March 1804 to 1817, Birmingham supplied to the Board of Ordnance 3,037,644 gun and other fire-arm barrels, and made 2,879,203 locks for rifles, carabines, and pistols, besides furnishing materials for 1,000,000 guns for the East Indies, and for its own trade 500,000 fowling-pieces. In a national point of view, the importance of the manufacture of guns is increased, by a knowledge of the fact that the Royal Gun Factory and manufacturers in London, from 1803 to 1816, produced 845,366 military guns. The total number of complete fire-arms produced in Birmingham, from 1804 to 1815 inclusive, reached 5,000,000, or at the rate of 416,668 per annum; and in the ten years from 1854 to 1864 (including the Enfield production), to 611,630. By comparison, the Belgian for forty-four years, from 1820 to 1864, is considerably under the English rate of production (even at the former period in 1804 to 1815, it amounted only to 403,360 per annum), while 11⅓ years of the production of ten arsenal factories (September 1802, to December 1814) in France average only 216,639 per annum.

Tested by money value, the result is also in favour of England. In eight years, 1857 to 1864, the average value of guns exported by France amounted to 366,264*l.* per annum. Belgium in ten years, 1855 to 1864, exported 6,842,264 guns at 24*s.* each, value 8,210,716*l.* England in the same period exported 4,632,954 at 32*s.* 5*d.*, and 978,249 at 60*s.* each, value 10,443,993*l.*

The fluctuating nature of the gun trade is an observable feature. From the peace of 1815 but little was done in military arms, until the Crimean war, save the conversion of the flint locks of the old "Brown Bess" into percussion locks, while subsequently the American and Franco-German wars were important influences.

NAILS.

BY THE LATE W. C. AITKEN (Birmingham).

IF the importance of an industry is to be estimated by the number of individuals engaged therein, one of the largest in the "hardware" division of manufactures would be that of wrought nails (made by hand), though the once numerous "hands" employed are rapidly decreasing. In 1830 it was estimated that 50,000 men, women, and children were working, but in 1861 the number only amounted to 26,000, and now (1874) the number employed scarcely exceeds 23,000. This arises no doubt from the introduction of machinery for the production of "cut" and "machine-wrought" nails, which, particularly the "cut," are rapidly displacing the "hand-made" nail in the market. This is scarcely to be regretted, as the condition socially and intellectually of those employed in the hand-made nail trade from the commencement down to the present time has ever been low.

Nail making in this country can be distinctly traced to the improvements in the manufacture of iron, and particularly the introduction of "slitting" mills, by Shutz, a German, who arrived in this country in 1565, and was associated with William Humphrey (the then English Assay Master) in the management of Mines

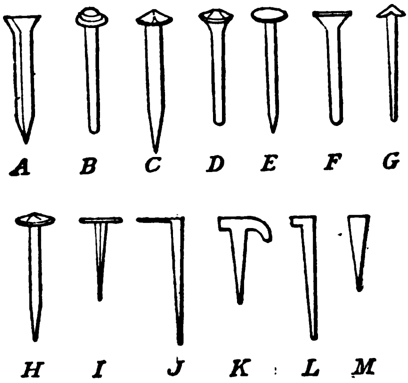
Royal, Mineral and Battery Works, the property of the Crown. These mills supplied nailers with raw material, in the form of "slit" rods; the trade in consequence grew, and became localized where it now is. The chief centre of the nail trade is in the towns, villages, and hamlets around Dudley and Bromsgrove, an ancestor of the Foley family in 1600 having set up a slitting mill at his iron works near Stanbridge.

The condition of the nailers in the early part of the reign of Queen Anne (1713) appears to have even then attracted attention, and in 'An Essay to Enable the Necessitous Poor to Pay Taxes' it was stated that nailers worked from four o'clock on Monday morning to late on Saturday, to get 3*s.* per week, that sum being frequently reduced by the bad iron supplied. The remedy suggested was an extra advance of 6*d.* on every 1000 of nails, to be apportioned as follows: 2*d.* to the nailer, 1*d.* for a schoolmaster, school, books, and clothes for the nailer and his children, "to educate them to read their Bibles, and to write, that they may know their duty towards God and man, and to know themselves;" 1*d.* went to the wholesale dealer, and 2*d.* to the "Corporation of Mines," &c. It is to be regretted that the reports of two Government commissions, appointed respectively in the years 1841 and 1855, to inquire into the employment of children, disclosed the melancholy facts that the lapse of nearly 150 years had neither improved the dwellings, workshops, nor habits of a male or female nailer, and the education of their children, till now, has continued to be neglected.

There are no large manufactories in which numbers of nailers work under one roof. Nail making by hand is essentially a home trade, practised in small sheds, or shops, attached to dwellings, in which not unfrequently the father, his sons, and daughters work together. The "forges" are rarely more than 15 feet by 12 feet (the ordinary size is 10 by 9 feet), and the only means of ventilation is by the door, and of lighting, by two unglazed apertures, while the interior is filthily dirty. The advantage taken of female labour in the trade is peculiar. One hundred and forty years ago, Hutton, in his journey to Birmingham, in the neighbourhood of Walsall, saw numbers of scantily clad women at work in little "smithies," and on inquiring if they shod horses, he was told they were nailers. Of the 26,000 individuals employed in the trade in 1861, nearly 11,000 were females. Division of labour enters into the nail trade, in so far as certain nailers confine themselves to the production of only one kind of nail, the maker of "horse-shoeing nails" rarely or never making "rose" or "clasp," while the "tack" maker in turn confines himself to his speciality. The rapidity with which nails may be made is illustrated by the fact, that in two weeks a workman made 40,800 flooring "clasps," each of which was struck by a hammer weighing 2 lb. twenty-five times, including the welding together pieces of nail rods which had become too short to work. The number of blows struck amounted to 1,033,656; the rods were heated 42,836 times: a good example of rapidity, skill, and minuteness. The smallest variety of "tacks" sold, weighs 4 oz. per 1000; and not unfrequently a skilful tack maker produced an equal number which did not exceed 20 grains in weight, and so small that they could all go into the barrel of a goose quill.

The name "nail" is generally applied to all kinds of nails, but the several varieties with special names are legion, and are well known by those who use or sell them. An ordinary trade list embraces some thirty varieties, some being sold per lb. or per cwt., others per 1000; but when 1000 is purchased (unless by "tale"), the purchaser only exceptionally gets his number, in all likelihood only between 750 and 1000, though the nailer is paid by number or "tale" by the "nail master," who does not count, but weighs the nails.

The varieties of nails usually sold, consist of Rose and Flemish tacks, varying in length from ¼ up to ⅞ of an inch; there are other nails tack-like in form, larger in head, longer and thicker in shank, known as "Clout," "Sacking," "Slute," "Tray," and "Saddler's" nails. "Rose" headed are distinguished by the head being elevated slightly, while on it four blows of the hammer are distinctly visible; "Clasp," by the head being formed by only two blows of the hammer. It is used in "flooring," and as it sinks readily below the surface of the wood into which it is driven, it is used generally for woodwork planed over after being put together. "Brads," which have only the indication of a head at one side, are produced by one blow of the hammer. These form the great bulk of hand-made nails produced in England, the remainder being made up of horse, Kent and Essex hurdle, gate, pipe, plate, scupper, mop nails, and spikes, to which should be added the varieties used by the heavy shoe trade, as hobs, "sparrables," or "sparrow-bills," "tips," and "clenchers"; "tenter" hooks, formerly used by dyers, &c., to dry the cloth dyed by them, are also made by nailers. Each has its special qualities distinguished by such terms as Fine, Best, Best Best, and Weighty, while others made for export purposes bear the names of the several countries and the timbers for which they are intended; the nails made for Australia, for instance, would be rejected by the inhabitants of a colony or country where the wood is of a softer quality, and *vice versâ*.



A. Horse nail.
B. Mop nail.
C. Rose nail.
D. Dog nail.
E. Clout nail.
F. Countersunk-head nail.
G. Clasp nail.
H. Kent hurdle.
I. Tack.
J. Tenter-hook.
K. & M. Sparrables.
L. Joiner's and Brad.

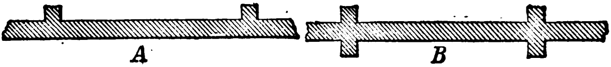
Nail makers rarely work for themselves or their own profit, but for employers called "nail masters," who have warehouses in the districts where the trade is situated, and who, on certain days, give out nail rods to be worked up during the week. The nailer is paid for the quantity produced either in money or goods (by the "truck" system), the latter being generally high in price, and realizing a large profit to the nail master.

The nail shop is small, and usually dirty, containing a pair of bellows, and small anvils mounted on low blocks, on which is fixed a chisel; the only tools, strictly speaking, being a peculiarly formed hammer, having a head with but one striking face, inclining towards the handle. The remaining tools are pieces of steel, perforated at both ends, and a "bolster" through which to drop the pronged spike of the nail, in order to form the head; and with these simple appliances and tools the nail maker gets to work. He heats the nail rod on his hearth fire, by means of his bellows, turns to his anvil, rod in hand, and with a few blows of his hammer converts the blunt end of the rod into the spike of a nail, which is cut to length on the chisel while still attached to the rod; then seizing the "bolster," he drops the spike into one of its two holes, separates it from the rod, and by a few more blows converts the surplus iron projecting out of the bolster into a head. Other rods, ready heated, are withdrawn from the fire, and the operation repeated with great rapidity.

All "headed" nails are thus produced, except those of larger size, with ornamental, or moulded convex heads, such as door studs, or for fixing upright water spouting, in which the head is formed by a "swage" or die, or a double hammer, called an "oliver," worked by treadles connected with cords; one hammer draws out the shank, while the spike end is dropped into a "bolster" under the other, which bears a die with a design for the head. The workman presses on the treadle, causes the hammer to descend on the piece of iron that protrudes from the surface of the bolster, and the ornamental head is produced. Horse nails are not "bolstered," the head being a part of the shank to fit into the groove which traverses the under surface of the "shoe," and formed at the same time as the shank by the hammer only.

Patent machine-wrought nails up to the present time have been slowly, but gradually, finding their way into the market, selected in preference to "cut" by purchasers who consider hand-wrought as the best nail, but recognize in the machine-wrought many of its qualities, while the cost is less. Hitherto, the machine-made have been confined chiefly to the production of a very few varieties, such as "Rose," "Clasp," and "Horse"; the characteristics of hand-wrought are well preserved, except as regards sharpness of the external angles of the shank: and there is a peculiarity in the form of the head of the clasp, in both "Clasp" and "Rose." The grip of the die to form the head in the former compresses the shank immediately under the head, while in the latter variety, it widens or flattens the shank laterally. The shanks are thinner than their terminations, and this peculiarity compensates for the hold gained by the sharp angles of hand-wrought, or the sharp and minutely rough angle of the cut nail; the wood being elastic, when the machine-wrought nail is driven immediately under the head, the wood clings to the nail by its spring, and presents a resistance to its withdrawal, which apparently compensates for the want of the properties alluded to in the hand-made and the cut nail. Two characteristics are possessed by the hand-made over the machine-made nail, viz. elasticity and rigidity, and no system of compression by rolling will produce the uniform sharpness of angle, nor impart the rigid elastic property which can be obtained by percussion, resulting from the rapid blows of the nailer's hammer. And these attributes alone will ensure a demand for hand-wrought nails, especially "Horse," in preference to machine-wrought.

Any description of the machines now used for patent wrought nails, by mere words, without the aid of illustrations, is impossible, for they are very complex from the multiplicity of the many separate pieces, such as cams, levers, wheels, heading bars, die holders, and dies, united in each machine. The earliest effort to compete with the hand-wrought nail was attempted in 1790 by means of rolling. On the circumference of a pair of rolls was incised or sunk a series of representations corresponding in intaglio to half a nail (if slit up longitudinally); and on the rolls being set in motion, a heated rod was taken in by them, and issued out as a string of nails, which only required to be disconnected, and the superfluous metal removed. But this took time, and there was a difficulty in regulating or "registering" the rolls, viz. placing half heads and shanks on the one in proper relation to those on the other. The action of the rolls also necessitated a peculiarity in cutting the die, in order to relieve the metal forming the head, its under surface not being at right angles with the shank, but slightly convex instead of concave. The difference will be at once understood by comparing a well-made hand-wrought nail head, with that of an ordinary wood screw. The latter is a somewhat exaggerated illustration, but it serves to show the defect of the head produced by the rolling process. This method of producing wrought nails has been entirely discontinued.



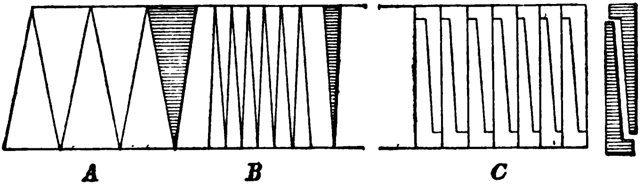
Section of single A and double B ridge, rolled iron, used in the manufacture of machine "wrought"-made nails.

The most recent method of manufacturing patent wrought nails is from iron, produced by means of grooved rolls, having either one or two ridges raised on its surface, the former, if for "brads," the latter if for rose headed, or clasp, &c. The ridges cross the strut in order to preserve the fibre of the iron parallel with the length of the nail, and the sheet is cut up into breadths which have on one side a single A or double ridge B, according to the variety of nail required. These strips are next heated, presented to the machine, drawn in by it, cut by a "slicer" crossways into breadths, each of which ultimately forms a nail, which are picked up by a "carrier" forming part of the machine, and placed in a "grip" made by three dies. The "slicer" alluded to forms the fourth side, and is firmly held during the process of tapering (accomplished by the pressure of a roller die). While in this position, a die, with a depression corresponding to the form of the head of the nail, is impelled against the surplus projecting metal, and converts it into a finished head, the complete nail dropping out of the machine. In addition to the two methods described, the attempts to simplify the production of "wrought" nails have been very numerous during the last eighty years; but these consisted rather in accomplishing the end by a series of machines than by one, in which all the processes required to form a nail were united; as in Mr. Coates' patent in 1841, which he improved upon in 1844, and again in 1850. The principle was again adopted, and with the addition of the "ridge" rolled iron (out of which to cut the nail "blanks"), was repatented in 1859; and it must necessarily be included in all future machines for the manufacture of patent wrought nails. It may be added, that the present method of producing machine-made wrought nails is a hybrid process, between cut and wrought nail making, the shank being cut, and the heading and pointing being done, by a die and a roller.

CUT NAILS.

It has been shown that the production by the patent machine-wrought system is limited, the nails being formed while the iron is *heated*. In cut nails the metal is operated upon *cold;* pointing forms a special operation in both hand and machine-wrought nails; but in cut nails, the production of shank and point is simultaneous. It is only when the cut nail requires to be "headed," that an additional process is added, though performed by the same machine with which the cutting is accomplished. The varieties produced are not so numerous as in the hand-made, and consist of *Brads*, distinguished as floor, strong joiner, extra strong, fine cabinet, chair, and brush. "Rose" varieties are divided into "fine," "strong," and "Canada"; "Clasps" are "fine" and "strong," and to these may be added "clasp" headed spikes, from 5 inches in length, and upwards, fine and strong Flemish tacks from ¼ inch up to ¾ inch. "Clouts" are used principally for box making, or nailing up "laths," and commence at ⅞ inch and rise up to 2½ inches. Patten and clog tacks begin at ¾ inch and terminate at 1¼ inch; sacking, slate nails, shoe tacks, and round head clog and patten, from ¾ inch up to 1¼ inch; smaller varieties from ⅜ to ⅝. Nearly every variety of nail made by hand may be produced by cutting, except piping, plate, and horse nails. Cut nails are usually sold by weight; so far as price is concerned, they are considerably under either of the varieties, hand or machine made, already described. Thus in 2½-inch nails, the cut are now sold at 22*l.* 10*s.* per ton, the hand-wrought at 26*l.*, and the patent machine-wrought at the intermediate price of 23*l.* 3*s.* 4*d.*

All cut nails are produced from strips of iron cut from sheets, the breadth of the strips corresponding to the length of the nail. Care is taken that the fibre of the iron runs parallel to the length of the nail, by laying a number of joiner's "sprigs" (B) or shoemaker's "sparrables" (A) head to point alternately; and thus a strip is reproduced, corresponding in breadth to that from which they were cut. Brads (C) are also cut out of each other from a strip broader by the head; in the production of these, or any other cut nails, there is no scrap or waste.



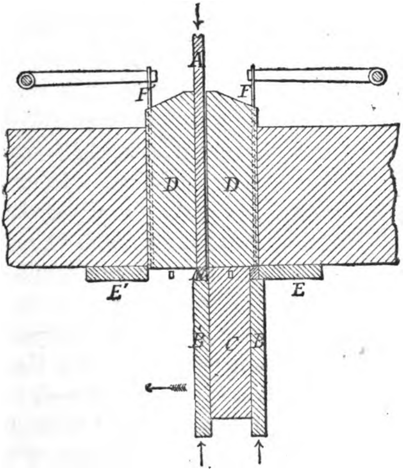
Strip to illustrate cutting of Sprigs, Sparrow-bills, and Brads.

"Headed" cut nails, as rose, clasp, slate, clout, and those of the "tack" group, are simply larger "sprigs," wedge-like in breadth, equal in thickness to the sheet iron from which they are made. After they are cut off from the strip, by the slicer of the nail-cutting machine, they drop into, and are firmly clutched by grips, and a heading die carried by a sliding bar "upsets" the iron projecting from the grips and converts it into a head.

The cut on the opposite page will illustrate more clearly the operation of the machine used. The best machines are all self-feeding, and also impart to the strip the vibratory motion to produce the taper-formed shank of the future nail. The rate or speed at which these machines work will produce of the larger varieties of headed nails from 80 to 100 per minute, while a sprig, sparrow-bill, or "sparrable" making machine operating on five strips at once, will produce 1000 per minute.

The after-finish of tacks, or nails which are blue, black, or tinned, is as follows. The blue colour is the result of placing the cut tacks in an iron cylinder and subjecting them to the heat of a muffle, and when the required shade is obtained, they are withdrawn and allowed to cool. The black is produced by immersing the tacks in black varnish and then drying them in a stove. The white, i.e. "tinned" tacks are coated with tin by immersion in a bath of that metal in a state of fusion, the tacks having been previously cleansed by the action of sulphuric acid diluted with water.

The origin of the cut nail trade, as it now exists, is due to a Joseph Dyer, who in 1814 at Birmingham combined in one the operations accomplished by several machines, and thus laid the foundation of the manufacture. Its chief seat is Birmingham, where not less than 18,000 tons of iron are consumed annually, two firms alone absorbing 8000 tons of this quantity. A considerable bulk of the cut nails produced are exported to India, Australia, and other British colonies, the high duty preventing their introduction into other



Double-action Nail-cutting and Heading Machine.

The nail strip A is placed in a feed box, vertically or horizontally, and receives a vibratory motion to give the taper to it; the strip is pressed upon by a spring, to keep it in contact with the slicers.

The top slicers are fixed in the framework of the machine, as are also the back dies E′ E, while the bed shear C with its bottom dies B′ B is moved to and fro in a slide.

The cut shows the slide at its farthest point of stroke on the right-hand side; a nail blank is pressed against the back die E′, and the bottom die E is lifted up vertically. Thus the blank is firmly held upon four sides, while the heading bar is brought into action upon the end of the blank to be "headed." After it is cut off, it is advanced by a finger F′ just as much as is required to form the head. The instant the nail is headed, the dies C and B travel in the direction of the arm, by which time the nail strip A is in its place for the slicer to cut off another blank; and on the return stroke of the slide, the headed nail is free and is pushed downwards by the finger F′ placed at the back of the top slicer D.

The slide carries the blank N against the die E, and the operation as described is repeated.

The machine represented is a double-action one, having two headers which operate alternately—i.e. on the retreat and return stroke.

countries. The Americans are very large consumers of cut nails, wood being extensively used in the construction of their habitations, especially in the States, backwoods, &c., and this doubtless stimulates the supply.

In England cut nail manufacturing is practised at Wolverhampton, Newport (Monmouthshire), Leeds, and Newcastle-on-Tyne. As in all similar manufactures where machinery has superseded human labour, high wages for the workpeople are confined to tool makers and the superintendents of machines, who get from 25*s.* to 55*s.* per week, ordinary workmen from 17*s.* to 25*s.*; women and girls nearly equal the males in number, and get from 7*s.* 6*d.* to 15*s.* per week; altogether about 2500 workpeople are employed in the trade.

Nails are also made from iron wire, a variety of French origin, as the name, "Pointes de Paris," indicates. They are made from 1 to 4 inches in length, and are well suited for, and principally used in, the construction of packing cases of willow, or other soft woods which grow so abundantly on the Continent. These nails drive freely and hold firmly, the material rendering them strong, while the parallelism of the shank presents an obstruction in withdrawing them when once driven. They are all made by machines, which cut the wire, "point," and "head," by means of advancing dies, the point formed by one die, the head by another, as in machines used in the formation of the heads of machine-made, wrought, and cut nails. The quantity of wire nails made is not great, for they are but little used in England, and only a few are manufactured for export purposes.

Nails are also cast, but their use is chiefly confined to horticultural purposes, such as the training of fruit trees against walls; hence their name "wall" nails. Cast nails are also used for the attachment of laths to the interior walls of buildings to hold the plaster. These have tapering shanks, square or triangular in section, and are cast in moulds formed of sand, from patterns which represent the heads only, the shanks being pricked in with a model representing the spike in the corresponding half of the mould, directly opposite the centre of the head pattern; or a complete pattern of the nail is projected through a thin metal plate, the head on one side, the spike protruding on the other. These are moulded in a two-part casting-flask, or mould, the head on one half, the stalk on the other. Sometimes the nail is laid in a longitudinal direction, one half on one side, the other half on the reverse of a thin metal plate, and then moulded. After the mould is made, the impressions produced by the patterns are connected to central "gets" or runners. The moulds being closed, are bound together with ordinary moulder's clamps, so that the iron in a state of fusion is run in and fills the prints made by the patterns. When cooled, the moulds are opened, and the nails disconnected or broken off from the "gets." Like all iron castings, these nails are brittle and frequently break in driving, which could only be obviated by annealing them in close iron boxes filled with hæmatite iron ore. This process, however, would be expensive, even when annealed, for the nails would not be equally so fitted for general use as are hand-wrought, machine-made, or cut nails.

Cast brass nails, with square or twisted shanks, are produced in small quantities for ship-building purposes, and of an alloy of copper and tin, chiefly used for the fastening of copper or patent sheeting to the hulls of ships below the flotation line, or water mark.

The earnings of those engaged in the hand-wrought nail trade vary very much. The children begin work as early as nine years of age, and at the age of ten or twelve are expected to make their "stint" of 1000 nails per day, despite the rapid decrease in the demand for hand-wrought nails.

There will always be a limited demand for wrought nails, more especially for those used in horse shoeing, the production of which by machinery has up till now been unsuccessful, and the quality of elasticity combined with rigidity produced by the operation of the hammer will never, in all probability, be produced by a machine. Fifty years ago the English Admiralty took upwards of 600 tons of wrought nails annually, but the weight now required by it is small; the demand from the United States and Canada has also materially decreased. The Belgians are our great competitors in this branch of national industry.

LOCKS.

By the late W. C. Aitken (Birmingham).

The early existence of the trade of Lock making in Wolverhampton and the neighbouring districts was in all probability due to the excellence of the iron, which, previous to the application of mineral fuel by Dud Dudley, was smelted with wood. Lock making was in 1686 the chief trade of this town, and in 1732 it was written, "The chief manufacturers of this town are *locksmiths*, reckoned the most expert in England." Though Wolverhampton is the depôt where locks are most generally purchased, the great centre of the manufacture is Willenhall (a short distance from Wolverhampton), of which place in 1801 a county historian wrote, "More locks are made here than in any other town of the same size in England or Europe."

The lock trade affords employment in Staffordshire to at least upwards of 5000 of its population, in Wolverhampton, Willenhall, Walsall, and Wednesfield, to which may be added the large villages of Bloxwich, Short Heath, and Brewood.

The word "lock" to the uninitiated suggests simply a means of fastening a door, chest, &c., but the kinds of locks are very numerous, one large firm making 1700 different patterns, while each town has a reputation for the excellence of special varieties, for instance, Wolverhampton for its till, cabinet, levered rim, mortise, and fine plate locks; Willenhall and its suburb, Short Heath, for warded rim, dead, mortise, drawback, pad, and till; Walsall and Bloxwich for their iron pad, and cabinet; Wednesfield for its iron cabinet, and keys; Brewood for its fine plate.

The peculiarities and fitness of locks for special purposes rather than their mechanical construction must, from my limited space, form the leading feature of this brief notice of a very large industry.

The various kinds of locks are classed under three divisions: first, brass cabinet and other best locks; second, bright and japanned iron cabinet and other common locks; third, stock (plate) or locks with cases of wood, i. e. the ironwork of the lock is attached to a thin plate of iron, which is sunk into the wood "stock" or frame. The first division consists of such locks as are applied to tills or drawers—hence named "*till*" or "*drawer*." Then follow *straight cupboard*, which do not require the wood to which they are fixed to be cut away, or cut out, for the reception of the metal cover which contains the working parts of the lock. *Cut cupboard*, on the contrary, necessitates the cutting away of the wood for this cover, as also the metal plate to which the works are attached, so that the lock should not project from the wood on which it is fixed, into the interior of the cupboard or drawer. This variety of lock is intended to be sunk flush with the wood, &c. *Double-handed cupboard* locks shoot the bolt of the lock either to the right or left hand. *Pedestal or sideboard* have the peculiarity, that instead of the bolt, or bolts, shooting into wood, or "stile," two-eyed staples or hooked pieces of metal are attached to a plate and fastened to the "stile" into which the "bolts" shoot; this peculiarity of construction is carried out also in box, or sloping, camp, and travelling desk locks; in some varieties of which the bolts of the locks are hooks, and lock by the hooks passing behind a striking plate. The same peculiarity is also observed in such locks as are used in portfolios, carpet and letter bags, and book edges, as ledgers, &c. In trunk and portmanteau locks, the plate on which the staple, &c., is attached (into which the bolt shoots), is hinged, the hinging permitting the withdrawal of the staple from the lock, when the portmanteau, &c., is required to be opened.

The locks dealt with hitherto are all small in size and of such kinds as are used for articles of furniture, and hence the distinguishing name of "*cabinet*" locks for those used by cabinet makers; the others being applied to articles made by desk and dressing-case makers, bookbinders, and saddlers.

The numerous and larger examples of locks in use by builders and carpenters for house building will next be described.

Dead rim locks, to lock on one side only, have the works of the lock encased in frames of metal, usually of japanned iron. They are applied to the interior side of the door, the distinction "dead" being a trade designation, meaning that the bolt can only be shot out or in by the key. The same appellation to lock on both sides, means that the bolt can be withdrawn by introducing and turning the key either from the in- or outside of the door. *Spring rim* or *drawback* locks have but one bolt with the addition of a *spring*, which, on the use of the key, permits the bolt to be withdrawn by a knob on the inside of the door. The same kinds of locks are made with *three* bolts, i. e. a *spring* latch, a *main*, and a *private* bolt, the first-named bolt worked by a knob, the second (*main*) bolt by the key, and the third (*private bolt*) by a slide thumb-bit. With the *mortise* lock, the artistic features or the opportunity for the introduction of ornament on its external surface were at end, for even the *brass-cased* rim lock simply consisted in the case being made of brass instead of being of iron and japanned. The *mortise* is a lock which is hidden in the wood of the door, by cutting out, by mortising, the necessary wood to accommodate the usually oblong iron box that contains the works of the lock. In *two* and *three bolt* mortise locks, the bolts operate in the manner described as in rim locks, with the exception that the private bolt is operated upon by a small knob in the interior of the door, instead of by a thumb-bit, which moves the private bolt in the rim lock. *Plate* locks are those, in which the works attached to a plate of steel are let into "stocks," or oblong pieces of wood, and thereby attached to the door by screws or bolts. When used for ecclesiastical buildings, the stock is generally made of oak wood, decorated with iron plates with tre- or cinqfoil perforations, the plates further enriched by their outline, like their perforation, being of a mediæval character. Various kinds of plate locks are distinguished by the terms Fancy, Bastard, Fine, Best Fine, Best Best, Irish, Common, Best, and Barrack. *Latches* are included in the category of locks, and their mechanism is almost as varied as that of locks. *Combination* latches possess this property, that unless all the latch bolts are placed in one position, the door to which the latch is fixed cannot be undone. Flush, rim, and mortise, as applied to latches, simply mean that the first-named is let into the door *flush* with the wood, the second is fastened *on* the surface of the wood, and the third is sunk *into*, and entirely hidden in a suitably formed cavity which has been produced by mortising the door. *Padlocks* are a very numerous family, and may be said to consist of locks which are independent of what they lock. The iron loop of the padlock lifts up and is passed through a staple, the end of the loop being perforated with a square hole for the reception of the bolt; the end of the loop is then placed *in situ* within the body of the padlock, and the key turned, when the bolt passes through the hole. There are padlocks made with and without tumblers, as well as spring, and screw key padlocks, i. e. the key terminates in a screw, which, on reaching the bolt, unlocks it. Akin to padlocks, there are combination or letter locks, which open by means of letters punched round the outer circumference of thin collar-like cylinders of brass, and by moving the collars round on the bolt, the letters are combined so as to spell certain words; the combination allows the bolt to be withdrawn, and the lock is thus opened by a mental, and not a material key. The mention of keys reminds us that they were once highly ornamented with appropriate decorations, bearing reference to the locks to which they belonged, while even the wards formed beautiful devices and initial letters. Keys now are made of a purely utilitarian form, for use rather than ornament.

I have not the space to deal with the construction of other than those of an ordinary commercial character. The antiquity of locks is proved by numerous allusions to them in Sacred Writ and ancient poetry. The records of the inventive skill of our locksmiths are to be found enrolled in the volumes published by Her Majesty's Commissioners of Patents, such as the Marquis of Worcester's locks, which caught the hand of a stranger, as a trap catches a fox, and so far marked him that he might easily be detected. Eighty-four patents for locks were taken out between October 31, 1778, and April 15, 1851. Since the operation of the new patent law, in locks as in other articles, the number of patents has been vastly increased, and an immense impetus given to the improvement of the finish of locks, the use of superior tools, and consequently rapidity of production. Probably no industry has ever been so effectually and intelligently illustrated as that of locks, in the forty-four examples which formed the "Lock Trophy" in the Exhibition of 1851, the work of Mr. C. Aubin of Wolverhampton,—the series commencing with the simplest of locks and terminating with the Bramahs. With the invention of Barron, viz. the principle of allowing a stump on the "tumbler" to pass through a bolt, a principle still adhered to in the production of commercial and, it may be added, locks of superior quality, began a new era. The moveable tumblers *guarded* the fixed wards, and presented to those who tampered with them a difficulty which had not previously presented itself. The security of the Bramah lock lay in its nosle, curiously defended from the introduction of any but the proper key, by a new invention of a spiral spring, which by its operation prevented access to the bolt, to turn or shoot it. The principle appeared so perfect and unassailable, that for fifty years a padlock on the Bramah principle hung in the shop window of that firm in Piccadilly, with a board attached, on which was inscribed, "The artist who can make an instrument to pick this lock shall receive two hundred guineas, the moment it is produced." Various attempts were made to open the lock, but it was reserved as the crowning triumph of Mr. A. C. Hobbs, the inventor of Newell's paruotopic lock, to destroy the hitherto unlockable purity of the Barron padlock. He had previously, in twenty-five minutes, opened a three-bolt, six-tumbler lock, made by Chubb, fixed on the iron door of a vault in the occupation of the South-Eastern Railway Company. It, however, must be borne in mind, that the locks named were locks picked under circumstances which no burglar can possibly have in his favour, and that the opening of these two locks was effected only by a skilful and accomplished mechanic, as the invention of the paruotopic lock proved him to be. The actual time occupied in picking the Bramah padlock was twenty-two hours and forty-five minutes, but Mr. Hobbs afterwards picked the lock three times within one hour. It is probable that no cheaper nor more beneficial lesson was ever received, than that given by the American locksmith to the English lock trade. It is to the credit of Bramah, that at an early period he perceived the advantage of, and applied machinery to the production of his lock. The padlock, which required nearly two days of ordinary time to pick, was only 4 inches in diameter and 1¼ inch thick. The application of machinery to grind and cut the several parts of the interior mechanism of locks, and of skilful mechanics to fit together the parts machined, is on the true principle of the interchangeable system, the same which is now recognized in the production of guns by machinery; and by adopting this plan "most of the limbs of which a lock is composed are capable of being produced at a much cheaper rate, and with a degree of uniformity, impracticable by hand labour."

The manufacture of locks in the towns and villages in and around Wolverhampton, Willenhall, Walsall, Bloxwich, or the villages of Wednesfield and Brewood, is only exceptionally practised in connection with specially constructed manufactories. The great bulk of locks for exportation, and the cheap locks used in this country are produced by "master men," employing a few "hands," these chiefly apprentices. These masters have no capital, are very poor, and to enable them to live, go in and procure raw material; they dispose of their locks at a low price to Wolverhampton factories. Their tools are of the most crude and imperfect construction, though it is true that the cutting up of the sheet iron is now done by machinery, instead of, as formerly, by cutting out with the cold chisel. In some kinds of locks, as "plate" locks, the plates are still cut out and pierced, as also the bolts forged, by hand. The principal tools used in the locks of a better quality produced by "little masters," who work for Wolverhampton lock factors, are the shears, the file, and the punch. There is sad waste of material. The tools, not being attended to, work with difficulty, the shears wear in the cutting edges of the jaws, the pin becomes loose, while strength would be economized by the application of a counterpoise weight; children work these presses, and file, standing on blocks of wood, or boxes, to elevate them to the height of the vice in which the piece of metal is held. It is to be hoped that the distortion of the human form is less apparent now than when Mr. R. H. Horne, in his Report on this district, pointed out some years ago, that the protracted hours of labour at a vice tended to displace the right shoulder blade, and to bend the right leg inwards towards the knee. In the shops of small lock masters, children blow the bellows for those a little older to forge the iron, and the "drilling" of the pipe of a key for the reception of the pin of the lock, the cutting of the wards, and the filing of the keys are also done by young persons. Keys with more complicated wards are placed in the hands of more experienced adults and apprentices. The above conveys a very fair idea of the appliances in use, and indicates the class of human aid employed in the production of cheap tumbler cupboard locks of various kinds, so cheap as to be sold wholesale at 1*s.* 0½*d.* per dozen. Chest locks are sold at half the money, viz. 6½*d.* per dozen, and are so valueless in the estimation of their makers, that a workman engaged in chest lock making, dropping a lock, remarked to a friend who had picked it up, that he could make another "ere it had done ringing." Indeed, the locks which fall on the ground are left to be picked up by the boy who sweeps the shop. Four-inch common closet locks are sold at 7*d.* each, and those with fine wards at 11*d.* each, while common quality locks, with one wheel and a short "bitted" key, were sold in sets of five, for sets of drawers, with two keys, for 1*s.* 1*d.* per set. Small keys, which in 1810 were first "stamped" by Hope, of Ampton near Wolverhampton, out of wrought iron, were priced at 4*s.* 6*d.* per gross, in a list of that year, but are now sold at 1*s.* 8*d.* per gross, and, made of cast iron rendered "malleable," at half the money, viz. 10*d.* per gross. In 1816 the casting of keys was first introduced by Grove, of Birmingham, and all keys prior to the year 1806 were forged. The prejudices against stamped keys were such, that for a long period lock makers refused to use them. The cutting out of portions of locks from sheet iron by the fly press, punches, and bolsters, took place in 1790; this, and the conversion of cast into malleable were introduced into the lock trade in 1815, being due to Mr. Isaac Mason, of Bilston.

Among the curiosities of lock making produced in the great districts of lock industry, may be named a padlock, made in 1776 by one James Lee, upwards of sixty-three years of age, which, with its key, was not the weight of a silver twopenny piece; also a lock and key of iron not the weight of a silver penny; and he boasted that he could make a dozen locks with keys, which would not exceed the weight of a sixpence. A complete and effective lock on Barron's principle, full of "tumblers," was made just half-an-inch square, and under $\frac{1}{8}$th of an inch in thickness, by Henry Yates, of Wolverhampton. Mr. Chubb, in the Birmingham Exhibition of Manufactures in 1849, showed one of his patent "Detectors" set in a gold finger-ring, the lock and key weighing only sixteen grains. In the Exhibition of 1851, two boys, sons of Mr. Aubin, of Wolverhampton, exhibited a four-lever padlock only $\frac{3}{32}$ of an inch in diameter (small enough to go in a hemp-seed husk). But this was exceeded by Mark Sealiot, a blacksmith of London in 1578, who made a lock of iron, steel, and brass, consisting of eleven pieces, and a "pipe" key, which weighed only one grain.

As to the production of locks, Mr. J. C. Tildesley in 1865 estimated the number of employers at 450, who employed 4950 workmen, producing weekly of pad, cabinet, till, chest, rim, dead, mortise, drawback, fine-plate, secure-levered and other locks, in the aggregate 31,500 dozens, which, allowing forty-eight working weeks to the year, is equal to 368,000 dozens, or 4,416,000 single locks.

WOOD SCREWS.

By the late W. C. Aitken (Birmingham).

It will be readily understood that the trade term "wood screws" simply means iron screws used by carpenters and cabinet makers, varying in length and thickness from one quarter of an inch upwards, which offer a ready method of uniting separate pieces of wood, and attaching metal work to it. Screws, as everybody knows, are much more difficult to withdraw than nails, which from their tapering form, can easily be removed by a pair of pincers, while a well-made screw can only be removed through the same means by which it was introduced into the wood. Screws are distinguished by their lengths, and their thickness by numbers, viz. an inch screw may be had from $\frac{1}{8}$ up to $\frac{1}{4}$. The form of the head is usually distinguished as "countersunk," but there are other varieties, such as those with heads that are convex and stand in relief as half spheres (lock screws), while in others the heads are "bullet," like in form to those used by mediæval metal makers.

The crude machinery or processes produced rough and badly cut threads or "worms," which tore the fibres of the wood as they entered it, defeating to a very great extent the advantage of the worm. The bluntness of the point was also a disadvantage; but recent improvements in cutting, by which the bottom of the "thread" has been made flat instead of concave, and the points, "gimlet" like, permit of a smaller hole being perforated in the wood for the introduction of the screw, so that its smooth and well-cut thread does not destroy the fibre into which it is driven, and practically becomes a "nut." The perfection with which screws are now made has very largely increased the manufacture.

The early history of wood screws is involved in some little doubt. They were prior to 1760 entirely made by hand, but in that year the brothers Wyatt invented an apparatus for cutting them, which to a certain extent was automatic. The "blank" out of which the screw was to be produced was held by clams, which revolved in a power-driven lathe, and at the back of the spindle in which the clams were fixed, a screw arrangement repeatedly forced the blank forward through tools which cut the thread. The nicking of the head was also effected by revolving cutters, the blank, held in dies, being forced through these by means of a screw; and means were also provided for stopping and putting the machinery in motion. A curious illustration of the rate of production of screws by this machine, as well as the importance of the trade previous to 1798, will be gathered from the fact that Messrs. Shorthouse, Wood, and Co. (the then largest producers of screws), who had works at Burton-on-Trent, Tettenhall, and Hartshorne in Derbyshire, at the latter establishment with fifty-nine pairs of hands turned out 1200 gross weekly, which is under the

120th part of the production of one manufacturing firm in Birmingham alone.

All screw blanks were up to 1817 forged, but in that year Colbert, a German clock maker, devised a means for avoiding this, and forming the blanks from iron wire, so that apart from increased rapidity of production, the process gone through in converting iron into wire improved the metal out of which the blanks are made. By Colbert's process the wire was cut into lengths a little longer than the screw to be made, held in a pair of dies with a countersunk impression on their face, so that the wire protruding beyond the dies was "upset" by means of a hammer expanded laterally, and took the form sunk in the die. All screw blanks are now made from zinc, and Colbert's method has been improved upon. The wire is now simply supplied to the heading machine, into which it is drawn, and cut off to length, while the head is formed by a similar process to that described in solid headed pin making, the inventor of which, Mr. Wright, also brought out a screw-making machine, though from its complicated construction it never came into any extensive use, and has long been abandoned. Inventive skill has been largely exercised in this country and America in perfecting the machines, and those now in use here are American and self-acting. The attendance of women in the former dirty occupation of "screw grinding," as it was called, is entirely got rid of, and they are now employed in tending the machines, a number of which can be managed by one female.

The old process of screw making by hand consisted in cutting the rod into lengths, heating it, placing it in a countersunk bolster, and opening the head by hammering. The nick or slot on the head was cut with a hand-saw, and the worm of the screw, by placing the blank in clams at the end of a spindle, to the opposite end of which a winch handle was attached. The spindle, placed on two bearers, was made to revolve by manual power communicated to the winch handle. The dies which cut the thread were in two parts, the lower one fast and the upper loose, and connected with it was a lever with a weight attached, which, pressing upon the blank in its passage backwards and forwards through the dies, cut the thread. A treadle operating on the lever increased or diminished its pressure, till the worm was completed.

The present method is as follows:—The blanks, formed of wire as already described, are carried to the machine and placed in its hopper, whence by a mechanical arrangement they are withdrawn, one by one, and placed in the machine where the head is turned. They are then nicked, while held in grips by rotating saws, the burr arising from which is removed by again subjecting the blank head to the action of the turning tool; one complete revolution of the tool is sufficient to accomplish these two operations, and the blank is dropped down into a receiver. The headed and slit blanks are now placed in the hopper of the worming machine, and then taken to the clams; a cutter is next passed along the blank often enough to produce the thread of the required depth, and to form the point, and the screw is then released and falls into a receptacle provided for it. As these machines are self-acting, one woman can attend to a number of them, whereas of the preceding machines (on the interregnum system), one woman was required for each. Now, however, the supply of blanks to the hoppers and attention to the change of cutters (when they become worn) is all that is required.

Wood screws have also been produced by being cast in sand, and ingenious methods have been devised to simplify the perforation of the moulds, as regards the removal of the patterns; but it must be evident that any attempt to produce wood screws by sand casting, as beautifully clear in the worm or thread, as in the ordinary metal wood screw, must result in failure, whether as regards quality, utility, or price; metal when cast, whether iron, brass, or copper, is brittle in comparison with any of these metals, when they have undergone the processes of rolling and conversion into wire, from which all wood screws are made. Cast wood screws should be regarded simply as among the curiosities of manufacture.

Improvements in the manufacture of wood screws, with concurrent diminution in price, has led to their use in preference to nails. The computed number of screws made in England in 1849 was 70,000 gross per week. In 1866, this production had risen to 130,000 gross, and the quantity of wire consumed annually for this manufacture alone amounted to upwards of 5000 tons. In the year (1873) one manufacturing screw firm (Messrs. Nettlefold and Chamberlain) produced 150,000 gross weekly, or in the aggregate, allowing for stoppages, &c., forty-eight working weeks to the year, *seven millions two hundred thousand gross* of screws per annum. Birmingham is the chief seat of the wood screw manufacture, and they have not recently been produced to any extent elsewhere. The aggregate number made in England annually is at present estimated at 9,000,000 of grosses—or 1,296,000,000 wood screws. The iron wire consumed is nine thousand tons, though a small deduction should be made for screws from copper and brass wire.

RAILWAY BOLTS AND SPIKES.

THE LATE W. C. AITKEN (Birmingham).

FROM the very commencement of the railway system, it may be questioned whether its warmest advocates realized the new industries which it would call into existence, not the least important of which is the manufacture of bolts, nuts, spikes, fish, and wrought-iron chair plates, &c., now so extensively used, and imperatively called for in the making of railways; as also rivets employed in the construction of tubular bridges, as that of the Britannia; wrought-iron girders; stationary, locomotive, and marine engine boilers; gasometers, and tanks to contain water or other fluids. If in connection with the above, is considered the increase of steam-vessels, the multitude of rivets, bolts, &c., required in the construction of even a single iron vessel, such as an iron-clad, which now forms so essential an element in the British Navy, it will be owned that this industry is one well worthy of description.

In the fastenings used in railways of the best construction, every length of rail 18 feet long is connected with that which succeeds it, by two "fish" plates and four bolts and nuts, two of which pass through the former and two through the latter, holding firmly the two lengths together by the pressure of the nuts on the plates, on each side at the junction of the two lengths of rail. This forms the support of the length of each rail, which rests on seven "chairs," each of which is held down on the "sleeper" by "fang" bolts or "spikes." There are 542½ miles of railway between London and Aberdeen, laid down throughout as a double line, while at all the stations, the number of rails required for "sidings," &c., are very numerous. If however the estimate embraces the "fixings" on the 15,376 miles of railway now at work in the United Kingdom, their aggregate amount is equal to 361,500,000 of separate pieces used in the construction of the permanent way. But the employment of nuts, bolts, and spikes, &c., does not end here, for they enter into the construction of passenger carriages, waggons for the conveyance of merchandise, coal and minerals, live stock and luggage vans, and even into the framework of the locomotive by which they are all moved. A covered railway waggon alone absorbs in its construction nearly 300 bolts.

The system of division of labour is now such, that the screws required by black- and whitesmiths are no longer made by them; and the agricultural implement maker, or brass founder, who some years ago by means of screw plates or stocks and dies made his own screws, no longer makes, but procures them from the nut and bolt manufacturer in quantities. The system of standard gauges, founded upon micrometrical adjustment (introduced by Sir Joseph Whit worth), is such, that "bright" bolts formerly made by engineers and used in the construction of stationary, locomotive, and marine engines, in cotton and woollen spinning and weaving, are now produced by the nut and bolt manufacturer, with such extreme accuracy as to diameter, parallelism of shoulder of head, face of nut, and pitch of thread, as to prove how easily an universal system of screwage might be accomplished all over the world.

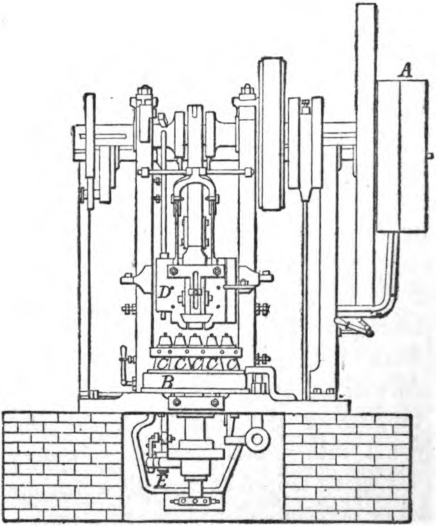
Large as are the requirements of English railways, those of foreign and colonial railways are still larger, and have, for the most part, to be supplied by English houses. Under the definition of "railway iron" these articles are included, and the results of a special and comparatively new industry therefore escapes notice. One firm alone, viz. the Patent Nut and Bolt Company, which has branches at the Stour Valley Works, near Birmingham, and Cwmbran Works, South Wales, can produce 100 tons per day of nuts and bolts, and at the rate of 30,000 tons per annum. Other and smaller establishments in the district, as at West Bromwich, Wolverhampton, the Black country, Sheffield, Glasgow, and elsewhere, will raise the consumption of iron in this department of British industry to 80,000 tons per annum.

It will at once be seen that the quantity required, together with the necessity for speedy execution, necessitates a greater degree of production than can be accomplished by manual labour; but "best" nuts and bolts, as they are called, are still produced by hand and forged by the workman, aided by a double "oliver," (or two hammers working by means of a treadle to each hammer). The assistant frequently treadles, while the chief workman turns round the heated iron on his anvil, lays it in "creases," or places it in "dies" in order to secure the form of the head of the bolt or spike, &c. Where the shank of the bolt has to be "screwed" with an external thread, and the nut "tapped" with an interior screw, these operations are performed by cleverly constructed machines, in which the bolt is held fast, and its shank screwed when in motion, by dies which thread it in its passage through them. The thread is not produced at once, but by the gradual compression of the dies in the advance and retrogressive motion of the bolt, by the automatic arrangement connected with the head of the screwing machine in which it is held. The grip or cut of the die is determined by the lever handle of the apparatus, in which the screwing dies are held, coming down on an iron stop when the bolt is finished, of uniform size and gauge.

The tapping of the nuts is effected with equal certainty, but with greater rapidity, as many as three or even six being tapped at once, by a machine either horizontal or perpendicular in its operation.

The taps used are all "taper" pointed, but terminate in "plug," or else they cut parallel towards the head, or taper taps prepare the nut for the plug tap; in either case, the plug or finishing tap produces a nut which moves by a gentle force on the thread of the previously screwed bolt. During the operation of tapping, the nuts are clutched, or held by grips in a horizontal or perpendicular position, the heads of the tap or taps being dropped into the ends of spindles prepared for their reception, and the screwing ends into the nuts. The machinery is set in motion and the taps being propelled forward, or downward perpendicularly, cut the worm in the nut; when the machinery is reversed

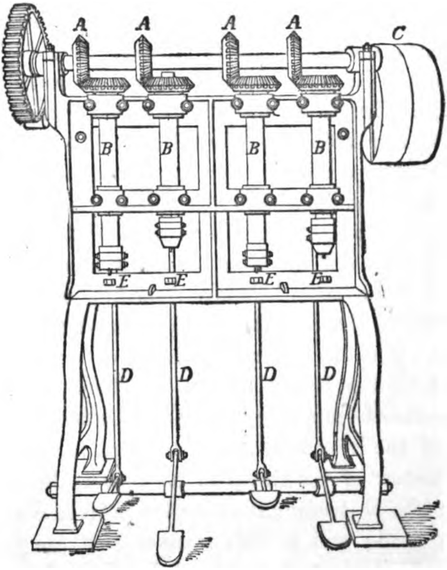
MACHINE FOR HEADING BOLTS, SPIKES, ETC.



A. Driving pulley. B. Revolving table.
C. Dies in which iron is placed.
D. Hammer of stamp carrying heading die.
E. For moving table.

and the taps are withdrawn, the nuts are removed from the clutches in which they were held, and if not for "bright engineers," the bolts are complete.

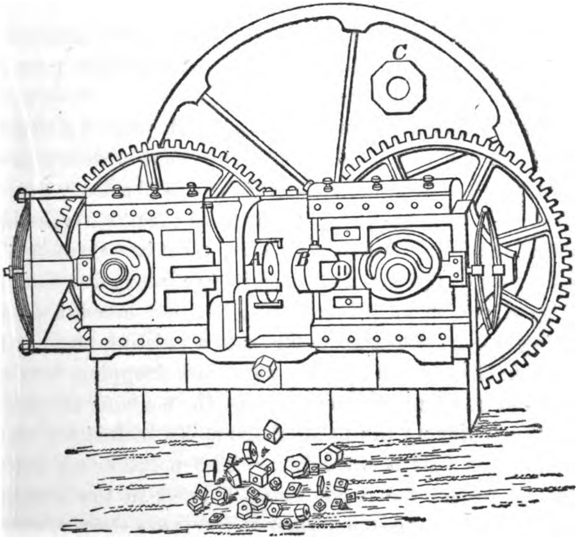
When bolts, nuts, and spikes are produced entirely by machinery, the process of producing the blanks or unfinished bolts or nuts is entirely different. Fish and fang bolts, with parallel square or round shanks and square heads, are made from round iron of suitable diameters or rods specially rolled. The rods are cut into lengths a little longer than the bolts required; the ends of the lengths to form the heads are heated in muffles with an iron side perforated with a number of holes, the size of the iron. By this arrangement the one end of the future bolt is cold, or kept comparatively rigid, while the opposite end is heated and rendered ductile. The heated iron is dropped perpendicularly into a socket or bolster die; if the shank is square, or of any other form under the head, a die bearing the impress of the intended head is attached to the descending hammer of the stamp in use; as it descends, the heated iron protruding from the lower die is compressed into a head; and in this manner also, are produced the peculiarly formed dog-headed spikes, their shanks made square, and their points chisel pointed, by being subjected to the operation of other machines previously. The operation of heading is considerably expedited by a machine with a revolving table, on which a number of dies are so arranged, that each, by a movement of the table, is brought under the falling hammer of the stamp, when, one blow having been given, the table is turned, and by an arrangement under the die, the headed bolt is forced out of the bolster and its place supplied by another piece of heated iron. The number of bolts headed is much larger than that made by the use of only a single heading machine. Nuts are entirely produced by either subjecting the heated flat iron bar in its length to the operation of a machine, which takes



A. Bevel-wheels, giving motion to
B. Spindles carrying (screwing) taps.
C. Pulley, which carries band.
D. Rods, which throw spindles in and out of gear.
E. Nuts to be tapped or in process of being tapped.

in, cuts off, and forms the nut round or square, and perforates the hole which is afterwards to be tapped;

MACHINE FOR MAKING NUTS.



A. Die to form external shape of nut.

B. Concentric punch which advances and cuts out the nuts; an internal punch then advances and perforates or punches out the hole.

C. End section of punch B.

or a bar of iron is heated at the end and presented to the action of a machine, with an advancing hollow punch fitted with another punch concentrically corresponding to the hole of the nut. This latter, which forms the external shape of the nut, is advanced by a cam, and the heated iron bar is held against the head. The hollow punch advances, cuts out a nut, forces it into a die or bed; the concentric perforating punch then advances and perforates the hole. The action of the machinery is then reversed, the double punch withdrawn, and the nut completed.

The longer kinds of rivets are made with a similar machine but with a different arrangement of dies, comprising a bed in which to drop the iron, and a die to compress and form the head. A twisted shanked spike is occasionally in demand, which is not cut or "threaded" by means of the screwing machinery already described. The shank is forged or rolled flat and broad, before being subjected to the operation of a twisting machine; it is held fast by the head, the shank dropping into a slot cut in an upright support, and the machine is set in motion, carrying the head of the spike with it for one quarter or half a revolution. The point being held firmly, resists, the result being a twist in the shank, which renders the spike, when driven into a sleeper, very difficult of removal. The operation of "twisting" the shank of the spike is accomplished with great rapidity.

Bolts, nuts, and spikes, the various modes of production of which have already been described, are sold in their rough black condition, screwed and fitted, utility only being considered. "Bright" or "finished" bolts and nuts, to be used by engineers require a greater amount of care. Every bolt is turned, every head is planed, every nut is faced; the bolt, while revolving in a lathe, is being turned, and parallelism through its entire length secured by the unerring operation of a tool fixed in a slide rest. The under part of the head is also turned, in order to "bed" or lie "dead" true, on the flange or surface of metal; and the formation of the thread or screw on the shank is produced, as also the corresponding nuts tapped, by machines as already described, but very much more perfect in their operation, on account of their superior construction. After the nuts are tapped, they are faced on their under surface by turning. Three or four according to their thickness, are next screwed together on a screwed mandril, their sides being operated upon while they are fixed under a horizontal planing machine, which acts upon each square, as it is presented to it. The sides of the heads of the bolts are also planed, and the nuts are then screwed on to the chuck of a lathe, which bears a male screw (corresponding to that of the bolt which the nut is intended to fit). The lathe is set in motion, and a slide-rest tool removes the extra iron, and equalizes the thickness of the nut; during the revolving of which the direction of the cutting tool is changed to a given angle, and the corners of the squares on the upper surfaces of the nut are bevelled off. During the turning and screwing operations, the tools, screwing dies, taps, and also the iron operated upon, are lubricated with soap and water, to cool the metal, and to facilitate the removal of the "turnings" and particles of metal, occasioned by the action of the dies and turning tools. Finally the squares or "flats" of the heads of the bolts and those of the nuts, are equalized and reduced to uniformity of size, while the longitudinal marks left by the planing machine, are removed by subjecting the nut and bolt to the action of two cutting discs placed on a mandril. The inner surfaces of the disc, opposite to each other, are cut like a file, and the heads of the bolt and nut are operated upon by placing them between the discs, changing the position of the nut and bolt, half the number of times that there are sides. Parallelism is accomplished and uniformity of size is secured, in order to fit the wrenches with which the bolts and nuts are gripped by the engineer, in fitting and screwing them up in connection with the engine or machine, of which they form an integral part.

The nut and bolt manufacturer produces materials for coaches and carriages, wood bedsteads, tyres of wheels, &c. Our telegraphic system is also furnished with insulating galvanized iron bolts for sustaining the wires, and wire fencing is also constructed by the aid of eye bolts.

The whole of this important manufacture may be said to be entirely due to George Stephenson, who, forty years ago, demonstrated the practicability of railways, and thus indirectly created subsidiary branches of industry, such as that of nuts and bolts, &c.

As in all branches of manufacture where quantities and speedy execution are elements, involving the necessity of machinery, the number of work people employed are few, compared with what they are in other national industries. In manufactories such as that of the Nut and Bolt Company, who make their own machines, skilled mechanics are employed, and in every establishment a superior class of workmen attends to the tools in use, the machines, and their repair.

Including the production of wood screws, the hands engaged number about 1800 males and 1500 females, in the aggregate about 3500. The machine makers, superintendents, and tool repairers, realize good wages; the females, in accordance with similar subordinate workers in other branches of industry. The intelligence and social position of those employed, is superior to that of operatives in the wrought-nail trade, except perhaps those who are engaged in the drudgery of the lowest processes.

BUTTONS.

By the late W. C. Aitken (Birmingham).

The various materials employed in the fabrication of these indispensable little fastenings, the quantity of raw material consumed, the inventive skill brought to bear on their manipulation, the rapidity with which certain operations are performed (even where these are executed by hand labour, owing to one individual engaging in one process only), the number of operatives employed, and the aggregate amount of money annually spent on the trade, demonstrate how important are buttons among British manufacturing industries.

Gilt metal buttons were made and worn in the early days of George III., though buttons of horn and bone were also in vogue. With the brief space at my command I can only enumerate the kinds of buttons made, the material out of which, and the processes by which they are formed.

Under the class of *metal* buttons are included—the plain flat gilt button once extensively used in the attire of civilians, together with naval and military buttons, made from an alloy called plating metal, which contained a larger proportion of copper and less zinc than ordinary brass. The devices were produced on their outer surface by stamping the previously cut-out "blanks" or metal discs into steel dies, while the necks were soldered on. Their finish consisted in gilding them with gold by the amalgam process, the gold being united with mercury applied in a paste and subjected to the influence of heat in a gilding muffle, in which the mercury here dissipated in fumes, while the gold attracted by the metal remained and was made bright and brilliant by the "button burnisher." There were other varieties of buttons made of very common brass, and some of bell-metal, hard and white, the necks of which were cast in, the surface of the buttons being made bright by abrasion, and finally polished on buffs. Ball buttons (hollow and spherical) were "raised" up from flat discs of metal, by a succession of tools worked in a press, the necks having previously been soldered to a "collet" of metal, which was set in and firmly secured to the spherical front by a pair of dies worked in a press. Occasionally ornamental perforated ball buttons, miscalled "filagree," were made, having their ornamentation stamped on and pierced, before the blanks were raised by the press into a spherical form, and gilt as before.

Buttons made of steel were worn on court costumes; they were bright and brilliant, the light gleaming from the many facets with which the button face was adorned, and for these immense prices were charged and paid. Matthew Boulton, who eventually largely aided James Watt, was in the early part of his career a manufacturer of steel buttons and buckles.

Three and four-holed brass brace buttons, formerly cast, are now produced from rolled sheet brass, the "blanks" being cut out either at the hand-press with a punch and bolster, or by a press worked by steam power, by which latter arrangement the work proceeds with an immensely increased rapidity. The operation of stamping causes the outer diameter of the blank to be increased in thickness, the name of the maker to be impressed thereon, and a depression made in the centre, so that the thread which attaches the button to the article of clothing may not project above the surface. The holes are sometimes pierced out by means of a hand press. Buttons in iron are produced from sheet iron in a similar manner to those of brass; and are also made of pewter, zinc, and tin. The introduction for personal wear of other material than broad cloth of uniform colour, such as tweeds for frock coats, called forth a class of buttons made in brass, with objects figured thereon, such as the heads of animals, in basso or alto-relievo. These were produced from carefully sunk steel dies by means of stamping; the backs with the necks being attached to the "shell" fronts, by being "set in" with an ingeniously made pair of press tools. The finish of these buttons was accomplished by means of chemical bronzes, i. e. oxides of metals dissolved in various diluted acids, by which process the metal was made to assume every hue, from the appearance of oxidized silver, through all the shades of colour of which metal is susceptible, so as to harmonize with the cloth, to which the button was to be attached. Recently, makers of metal buttons have introduced, in connection with the manufacture, the production of solitaires and sleeve-links, the shells of the best examples being produced, not from dies, but from carefully chased metal patterns. From these, moulds are made in guttapercha, covered on the impression side with bronze powder, and the external ornamentation of the solitaire or link is obtained by means of the electro deposition vat. These little fastenings are also finished by the application of acid bronzes, or the deposition of thin skins of various coloured metals by the electro-metallurgical process; and finally, their surfaces are protected by the application of lac spirit varnish.

There are also varieties of buttons made from the raw materials furnished by the animal, vegetable, and mineral worlds.

Upwards of a hundred years ago, the hoofs of animals supplied the material from which horn buttons were made. The property possessed by that substance, of becoming plastic on being heated, and yielding a copy in relief in a die into which it was pressed, determined its application for the production of buttons. The hoofs were boiled till they became soft, and cut into longitudinal strips by slicing with a long-bladed knife working lever-fashion in a staple, fixed on the workbench; and these strips were again cut across to produce squares, which were converted into octagonals by nipping off their corners. The blanks were dyed (if black, logwood and copperas were used), and the octagonal pieces of horn were placed in heated dies in which the design was cut, the die-holder having a hinged iron cover which was closed down on the plastic horn. The holder and its contents were next placed in a vice and subjected to its pressure, and then withdrawn. If the buttons had shanks of metal, these were attached by pressure, being laid in the die-holder in depressions to receive them. If the button was sewn on by three or four holes, these holes were made by four revolving drills.

Mother-o'-pearl buttons are made out of pearl shell, exported from the coasts of Macassar, Manilla, Bombay, the archipelago of the Pacific, the Bay of Panama, &c. The "blanks" are cut out of the shell by a steel tubular cutter, the face edge of which is toothed like a saw, and as it cuts through, small cylinders of pearl are disconnected, which are reduced in thickness by splitting into discs nearly the thickness of the button when finished. These blanks are completed on both sides by a steel tool, which produces the rim and depression in the centre of the button, &c. The two or four holes are drilled, as described in the perforation of horn buttons. The pearl button receives polish and brilliancy by friction with a mixture of rottenstone and soft soap while revolving. The best pearl buttons are those made from Macassar shells, and the best "black" from shells imported from the archipelago of the Pacific.

Ivory buttons are made from the tusks of elephants, and the material being expensive, the manipulation is conducted with greater care and chiefly by hand turning. A substitute for animal ivory was found in the kernel of the "Corozo" nut, which grows in clusters on palm-like trees in South America, and is husked like a cocoa-nut, but is smaller in size. The kernel, the part used in button-making, is milk white, softer than animal ivory, is easily turned, and readily absorbs the dyes, so as to suit the various coloured cloths.

Real stone buttons are cut from precious stones with a lapidary's "slicer," and then cut, "fawcetted," and polished, the blanks are perforated, where necessary, with copper drills revolving rapidly in a lathe, and the drills are touched from time to time with emery and oil.

Fancy glass buttons are made from "canes" of coloured glass, heated at the end, and pinched with plyer-like die tools, so that the impress on the die is transferred to them. The shank is introduced as in the manufacture of a horn button, or else a hole is pinched through the button, a long-shanked neck with a metal collar being passed through and riveted on the front side through an ornamental metal rosette. Other varieties are cut out of coloured sheet glass, the back of which has been "quickened," or coated on one side with rolled tin amalgamated with quicksilver, to render it reflective. The neck of the button is soldered to a small disc of metal, which is afterwards tinned on the opposite surface to that to which the shank is fastened, so that when the latter is heated, the solder fuses, melts the "quick," and the adhesion of the neck to the button is complete. These glass buttons are finished by grinding the edge and surface, if cut or fawcetted. Where "flashed" glass (i. e. glass of one colour coated over another) is used, the ornament is cut through the flashed colour with revolving copper tools like a cameo, and thus comes into contrast with the lower colour.

Wood buttons are made of various kinds, the commonest varieties from beech or box, stained black, brown, &c., after which they are turned, polished, and varnished. More expensive woods are used for better class buttons, as ebony, rose, and walnut. Buttons are also made from pulp papier-mâché by simply cutting out and receiving their final finish by varnishing, stoving, grinding with pumice-stone, and polishing by hand or with powdered rotten-stone. Buttons have also been produced from waste pearl shell, by grinding it down and mixing it with gum, thus producing a paste which, when heated, was pressed into dies. Leather has also been made into buttons by compression, the shank being previously introduced. China, too, has long been used as a material for buttons. Upwards of one hundred and sixty years ago, the French porcelain button makers formed a community, who, no doubt, made their buttons from wet clay. But a process by which the dry powder of porcelain clay was compressed into a solid button, glazed and fired, was invented by the late Mr. Richard Prosser, and practically carried out in England by the late Mr. Herbert Minton.

Covered buttons are made in such immense variety of textiles that it is impossible to enumerate them, but it is sufficient to state that their ingenious construction, their good wearing qualities, the clever mechanism of the tools by which the various discs of cloth, metal, millboard, &c., are cut out, and finally the methods of uniting these together into a complete button, are marvels of skill and industry.

The earliest covered button was made in 1802, by Mr. B. Sanders, of Birmingham. This one had a metal shank, but the ingenuity of the son completed the invention of the father, and by substituting for the rigid metal shank a tuft of canvas, through which the button could be sewn on to the coat, created the flexible shanked button. The only improvement made thereafter, consisted in covering the back of the silk-fronted button also with silk. A large increase in the demand for covered buttons speedily compensated for the decline of the gilt button, rewarded the inventors, and revived the flagging energies of manufacturers engaged in the button trade.

A covered button consists of two discs of metal, and one of millboard, thicker or thinner according to circumstances, a disc of silk, very much larger than either those of the metal or millboard, to cover the front of the button, and one of strong canvas to form the tuft or flexible shank, which protrudes through the perforated metal "collet" forming part of the *back* of the button. The metal discs have been made previous to placing the several component parts in the finishing die, that is to say, they have been cut out from very thin sheets of iron or "latten." If the button is intended to be convex in front, the flat disc of metal has been stamped convex, the name of the maker or trade mark being impressed by punches on the perforated disc which forms the back of it. Then a bolster or "lower die" is fastened to the bed of the press, while to the screw is attached a punch, which very nearly fits into a cylindrical cavity in the bolster (allowance being made for the united thickness of silk and metal). The silk is laid on the surface of the die in a sunk shallow space, with a paper one over it, to prevent injury, and lastly the thin iron disc is laid on in the centre of the paper. The punch, on turning the lever of the press, carries the discs down into the die, and converts them into a very flat shallow cylinder of metal, with a bottom externally covered with silk. The punch is now withdrawn by moving the lever handle of the press, and a cylindrical tubular steel tool is substituted, the hole down its centre permitting the remaining portions, which make up the covered button, to pass down; the tool is then forced down into the die, at the bottom of which the silk-covered iron shell rests, in its passage compelling the edges of the silk to "cove over" those of the iron shell. Lastly, the millboard disc, which determines the thickness, &c., of the button, the canvas disc, which eventually forms the flexible shank, and the perforated iron disc, stamped with the maker's name, are dropped down the hole in the tool, and a solid punch is passed after them, so that the edges of the silk disc are forced into the iron shell which retains them. All that remains is to force up the all but finished button, by the introduction of a wire, and to give the final pressure which permanently unites all the button together.

With a few slight modifications, the process of the manufacture described above embraces the variety of button called the "Florentine," also covered with silk, on which ornamental devices were woven, one of which, generally a flower, was introduced in the centre of each. This button was also patented by a Birmingham manufacturer, Mr. William Elliot, and so extensive was its sale, that sixty looms, constantly at work, were inadequate to supply the demand for the ornamental figured silk required in its production.

In a Birmingham button manufactory, employing four hundred hands, the consumption of raw materials was as follows:

	Yards.
Strong canvas	26,587½
Florentine lasting	47,865
Woollen cloth	162
Vesting textiles	398
Velvets and satins	639
Black and coloured silks and velvets ..	1,017
Black and coloured satins	1,182
Silk for "backs" of buttons	3,579
White linen drill	1,471½
Total	82,901

which in length would extend to 50½ miles, and cover 3 feet in width.

For front and back discs, which form the interior of covered buttons, 7 tons, or 15,680 lb. of best charcoal "latten" iron were used. To illustrate the economy of skilfully constructed cutting-out machines, I may state that 63,000 grosses of brace buttons (9,360,000) were cut and made from 2 tons of iron; 23,000 grosses or 3,120,000 buttons were made from rolled brass, mixtures of copper, and plated metal. In the production of light steel toys, i.e. buttons, clasps, and fastenings for ladies' dresses, the sheet steel converted into the above-named ornaments, exceeded in weight 5 tons.

In the twenty-three years which have elapsed since the above estimate was procured, the establishment has been largely added to, and 500 additional hands taken on; the consumption of material has been more than doubled, and in the production of buttons from the vegetable ivory, many tons of corozo are annually consumed.

Some years ago, between 1865 and 1870, the consumption of mother-o'-pearl shell amounted to nearly 1000 tons annually. The failure of the fisheries on the coast of Central America has now, however, reduced the consumption to a little more than one-third, or 300 tons annually. The pearl button trade would have been extinguished, but for the discovery of the valuable shell on the east and west coast of North Australia. We may estimate the value of

	£
300 tons of mother-o'-pearl shell at ..	55,000
800 tons of corozo nuts (vegetable ivory)	11,000
500 tons of various qualities of brass ..	65,000
1000 tons of latten and other iron	50,000
Tinned plate	60,000

representing an enormous sum in the manufacture of so insignificant looking an object as a button.

PINS.

By the late W. C. Aitken (Birmingham).

The use of pins as a simple means of fastening articles of dress, is no doubt coeval with the use of clothing, the thorn, or naturally formed spike, preceding all artificial pins, whether formed out of hard wood as box, or of bone, or ivory. More civilized nations, when a knowledge of metallurgy was arrived at, made them of metal, in all probability of bronze; for associated with needles of the same alloy, pins have been found in the sepulchres of Egypt. These, however, are longer than those now in use, and differ in being entirely taper from head to point. The heads of some were formed of gold, chased, and graved; others were simply bound with gold, the type of the pin made in this country and elsewhere, before the introduction of the now universally used solid-headed pin. It is said that domestic pins were first introduced into this country from France, in 1543, by the Queen of Henry VIII., previous to which time the fastenings in use consisted of ribbons, loop holes, clasps, crudely formed hooks and eyes, and skewers of wood, bone, brass, silver, or gold. The imported pin, or some of those imported, were of an inferior make; and the heads becoming loose, led to an Act being passed, prohibiting the sale of pins, unless they had "double headed" heads soldered fast to the shanks, shanks well smoothed and well shapen, points, round, filed, canted, and sharpened. Prior, however, to the importation alluded to, pins were enumerated as among prohibited imports. The first supply was received from France, and as the Act of 1543 distinctly refers to the heads being "double" and made fast, the imported article was doubtless made from "drawn" wire. Fournier, a Frenchman, who went to Nuremburg, taught the wire drawers of that city how to improve their original machines, and draw their wire finer, suggesting the idea that the art had been so improved in France as to render the wire fit for the production of pins, not only for shanks, but for heads; the wire out of which these were made being very much finer. Then, as now, the best pins were made in France of brass wire, but large quantities were made from iron, which were blanched and sold for brass; and the sale of the latter spurious article was in a short time confined to the Continent. It is curious however to remark, that in this country the great bulk of pins used during the period of mourning are made of iron wire and japanned black. How long pins continued to be imported after 1543, is doubtful, though in all probability it was, until the art of wire drawing (introduced into England in 1565) was so far advanced, as to produce wire suitable for pin making. The first manufactory in this country was began in 1626, by John Tilsby, in Gloucestershire, so successfully that it soon employed 1500 workpeople. The county was long celebrated for its pins, and the manufactories at

Stroud achieved a great reputation. In 1636, the pin makers of London were formed into a corporation, and the trade soon found its way to Bristol and Birmingham, where, in connection with a previously established wirework, it became localized. The introduction of a machine founded on the "Wright" principle by D. F. Taylor and Co. in 1824, entirely revolutionized the local pin manufacture, and converted Birmingham into the chief seat of that industry. Pin making is interesting, as it afforded the author of the 'Wealth of Nations' an example of the advantages of division of labour and economy of cost, arising from the employment of some 16 individuals in the 18 processes of pin making at that day. This labour is now reduced to the one workman who attends to the machine, the "colourer" of the pins, and the "paperer," three in all, while the work is better done, and the numbers of pins produced immensely increased. The processes employed in making the old wire-headed and the solid-headed pin, now in universal use, are as follows:

The material is brass wire of a lower quality than "best," but superior to the lowest quality of brass wire, it being more rigid than the best, and its surface better finished. The pin manufacturer is generally his own wire drawer, and if he does purchase the wire, he draws it down to the sizes that he requires, on his own premises, by the ordinary processes employed in wire drawing, in this particular differing from the needle maker, who purchases his steel wire ready drawn to the gauges from which he works his needles.

The firmly fixed solid-headed pin, equivalent to the soldered-headed of the Henry VIII. period, was attempted to be revived as a manufacture by Timothy Harris, in 1797, by casting on the heads, i. e. by laying the shanks into a two-part mould, in which prints representing the heads were cut. The mould was closed and an alloy of lead and antimony (type metal) poured in, while the pins, on being released, had the "gets" cut off, were cleansed by immersion in a "pickle" composed of sulphuric acid and water, dipped into a solution of sulphate of copper, "coloured" and finished as all brass pins now are. The production of a head made of twisted wire and how to fix it securely next attracted the attention of William Bundy, who thickened the wire by pressure into a collar, on which the head rested, to prevent its slipping down. The heads were placed on the shank in a die, while another die, worked in a fly press, descended, and compressed the top of the wires, securing the attachment of the wire head to the shank. In the production of the collar or thickening of the wire, it is not difficult to detect the embryo of the future solid-headed pin, now in universal use. In 1812 Bradbury and Weaver conceived the idea of "heading" by means of an automatic acting machine. The shanks being pointed and the wire heads prepared, they were put in separate hoppers, while a mechanical feeder placed a shank and head in relation to each other; and in this position the pins were pressed by screws against dies completing the external form of the heads, and uniting the head to the shank. The pins were then withdrawn by peculiarly formed hooks, operated upon by parallels worked by the machine. In 1817 Seth Hunt invented a machine for producing pins with "head, shaft, and point of one entire piece," thus realizing "a solid-headed pin." The wire was fed into the machine, cut into suitable lengths, and held by a die till the head was formed. The die was then rotated, and a pointing wheel was raised and brought into contact with the unpointed pin, against which it was kept in contact by a presser, till the point was completed and it dropped out. In 1824, W. L. Wright invented the solid-headed pin-making machine, which for many years was exhibited in London to crowds of visitors, and which, improved upon by D. F. Taylor and Co. and H. Shuttleworth, formed the basis of the improved, simplified, and compact machine now in use. Many prejudices existed against the introduction of the solid-headed pin; among others, that it bent more easily than the then ordinary wire-headed, owing to the wire being softened to facilitate the formation of the solid head, though, on the other hand, the loss of pins occasioned by wire heads coming off was forgotten. To this prejudice may be attributed in 1833 the machine invented by Brown, for the manufacture of wire-headed pins, in which the thick wire to form the shank, and the thinner wire which formed the head, were operated on by a machine simultaneously, viz. the small wire being coiled twice or thrice round the thicker wire of the shank, and compressed therein by the action of a pair of dies, cut to pin length, and conveyed to the pointing wheel of steel. Two grooves traversed its diameter, the one roughly tapering the shank, the other, of finer cut, completing and smoothing the point. It is unnecessary to pursue further the various improvements introduced afterwards, as they simply embrace methods which have become obsolete or profitless, and have, therefore, been abandoned. There are still a few wire-headed pins made, and as their manufacture has been selected by Adam Smith and Babbage to illustrate the advantages to the workman of division of labour and to the public in reducing price, the old method of making pins by hand will now be contrasted with the new or solid-headed pin made by machines, superintended by a minimum of individuals.

The *old* process of pin-making was conducted as follows: A bundle of brass wire was unwound, and the curve of its coils removed, by drawing it through seven round spikes driven into a horizontally placed bench, the wires being straightened in its passage through the spikes, cut into lengths of about 20 feet each laid parallel to each other, and finally cut with shears moved by hand or power into lengths (determined by gauges) sufficient to form six pins. These lengths were pointed at each end by a "grinder" or "pointer," applying the ends of the wires to the surface of a grindstone (in the earliest stage of manufacture), and, later on, to a steel disc or "mill," the circumference of which was "file" cut. During the operation, the grinder gave a rotatory motion to the wires, the point being finished on a more closely gritted grindstone, or on a finer cut steel disc, while the pointed wires were then cut off a pin's length from each end, and the operation of grinding and cutting repeated until six pin-shanks were produced from the one piece. The head of the pin, made of finer wire, was produced by winding it round a "spit" 36 or 40 inches in length, its external diameter corresponding to that of the shank to be headed. The mould was placed in a simple lathe, motion being given by hand; the wire was connected with the mould and guided and wound round it, so as to leave on the withdrawing of the spit an elastic spiral of wire, which was cut up into many separate parts, each equal to two revolutions of the spit, and each forming the head of one pin. The spirals were cut into heads, with shears, and the accuracy with which these were cut by the "head" spinner has been selected as an example of precision, arrived at by practice. The number of heads in one pound weight of wire in ordinary sized pins must have been very considerable. For the coarser varieties, the header was paid 2¾*d.* per lb., while smaller and finer pin heads were paid for at a higher rate. A head maker, according to ability, could produce from 6 lb. to 30 lb. per day, and out of his earnings he paid a boy assistant 2*s.* or 2*s.* 6*d.* per week. The heads, after being cut, were annealed or softened in order to make them cling more readily to the shank, and were next passed on to the "header," who secured them by a small stamp, the hammer of which was elevated by a cord connected with it, operated on by a treadle moved by the foot of the workman. The lower half of a pair of dies into which the pin dropped was then fixed to the "bed" of the stamp, the upper half having sunk in it a print to form the head, attached to the hammer. The header had a boy assistant to arrange the heads for the shanks, which he did by picking up a few of the latter and thrusting them among the heads, so that on withdrawing of the shanks, a very great proportion were found properly fitted. The stalks with their heads being then passed to the header, and dropped by him into the lower die, his foot pressing the treadle, so as to elevate the hammer. When the latter was released, by removing the pressure of the foot, it fell, when the blow expanded the head of the shank, compressed the wire head, and compelled it to cling to the shank of the pin, the form of the dies preventing the expansion of the head in a lateral direction. To obviate the difficulty of picking the pin out of the lower die, a spring was introduced, which after the blow was struck, elevated the pin and provided for its expeditious removal (an arrangement not unnecessary, when it is considered that an expert workman could only head 20,000 pins per day, for which he received 1*s.* 6*d.*; less expert workmen could only head from 10,000 to 15,000, and an assistant was paid out of the sum received.

A curious and interesting calculation (by Babbage) shows, that the labour of four men, four women, and two children for nearly seven hours and three-quarters was required to produce 1 lb. of No. 11 pins, the number of individual pins 5,546, the cost of the labour amounting to a fraction under 1*s.* 1*d.* Add to this the present price of brass wire at 11*d.* per lb., and the manufacture, expenses, and profit, and it will be seen that the consumption, demand for, and price of the pins now produced in the present day could only have been met by the introduction of automatic pin-making machines.

The manufacture of pins with solid heads produced by machines as invented by Wright (which forms the connecting link in the chain of pin-making), will next be contrasted with the operation of the improved machines now in use. In Wright's machines the wire was drawn from a reel with pincers, straightened in its passage by being drawn through studs, as in treating the wire for hand-made pins. The rotation of the shaft gave motion to cams, slides, and levers, working the different parts of the machine, while a pair of nippers cut off the length of wire to form a pin, the length regulated by screws operating in the gauge. A carrier took the pin length of wire, and held it against a roughly cut steel wheel which partially pointed it; a second carrier conveyed it to a wheel of finer cut, where the pointing was completed; and a third carried it to the heading bar. When the head was partially formed by a punch propelled against the "head" end of the pointed wire thus, a fourth carrier conveyed the pin to a second heading die, wherein the head was completed, and lastly the pin was seized by a forked lever and drawn out of the machine, falling into a tray below.

The improved machine now in use by D. F. Taylor and Co. is reduced in bulk and size in all its dimensions, being now only 24 inches wide by 30 inches long and 18 inches high. The wire is fed from a reel, straightened in its progress to the heading die; the heading is now the *first* instead of the *last* operation, in which it is grasped and converted into a head by *one* punch only, not *two*, as in Wright's machine. It is then cut off to pin length, which, descending by its own gravity, slides down a grooved incline and drops into a tray, the bottom of which has a slit in it to permit the shank to drop through. Here it is suspended by the head, shank down, in front of a revolving roller of steel, 1¼ inch diameter, cut over its entire circumference and length with files like teeth, diminishing in coarseness of cut from the left to the right hand; this roller operating on the suspended shanks in their progress down the slit (rotating as they move), have the points formed, smoothed, and finally polished; here they are forced out by other pins which are taking their places. The finished pins drop out into a trough immediately in front of, and under, the pointing roller.

All pins of brass, whether made by hand or manufactured by a machine, are coloured and brightened before they are offered for sale; and for this purpose, the pins, after they leave the maker or machine, are boiled first in weak beer to remove any grease, and to clean their surfaces. After arranging them in layers in a copper pan, alternating with layers of pure grain-tin, water is poured in, and the copper and its contents heated, while on the surface of the water cream of tartar, or argol (the deposit found in emptied wine casks) is sprinkled. By the action of the acid on the grain-tin, a solution of tin is produced, which is deposited on the surface of the pins, and they are then "coloured" (i. e. made to assume their white silvery appearance). If not whitened sufficiently, the operation is repeated. After their removal from the "copper," the pins are rinsed out between the "boilings" with clean water. Their brightness or finish is the result of shaking them with bran or sawdust, in a leather bag or "shaking" barrel, after which the contents of the bag or barrel are emptied, the bran or sawdust winnowed out, and the pins collected.

Mourning pins being formed of iron wire, if "blued," are subjected, after being cleansed, to the operation of heat on an iron plate, or in a muffle, until the blue tinge is obtained. The bright, or dead black colour is produced by immersing the iron pins in black varnish, withdrawing them after being coated, and drying the varnish in a stove. Lastly follows the operation of "papering" the finished pins, which are sold in pound weights, or in less quantities. The making up of the parcels is very easy, for they are simply weighed; but when sold in sheets, the making up and sticking in the pins into rows formerly involved not only time, but skill and quickness. Its cost was represented by nearly 3¼*d.* in the papering (of No. 11 for example), for there was the folding of 12 sheets of paper, each sheet requiring 24 double folds, followed by the operation of sticking therein 144 rows of pins, 39 in each row, or 5516 pins. All this was formerly done by hand, but has now been got rid of altogether, and a beautifully self-acting papering machine has taken its place. The pins to be stuck are fed into a hopper, in connection with which, a steel plate is used with longitudinal slips cut through it, corresponding to the number of pins which form a row. The pins in the hopper are now agitated by a comb-like tool, by the paperer's assistant; the shanks drop through the slits in the steel plate and are suspended by their heads, the stalks protruding on the under side; and near the machine are laid the long narrow sheets of paper with the address of the manufacturer (or retail dealer by whom they are to be sold) printed thereon. One of these slips is presented by the paperer to the action of the machine, by which two raised folds are crimped, while the row of pins collected in the slit steel plate is next subjected to the same action and pressed through the two crimped folds, and these operations are repeated until the twelve rows of pins in each sheet are stuck.

The simple and familiar word "pin," but imperfectly conveys an idea of the varieties or the numbers made of this invaluable mode of fastening. They vary in length and thickness from the 3½-inch "blanket" or "corker" pin, down to 2 inches in length, and "toilet" or "domestic" pins of finer wire, from 1½ inch down to only ⅝ inch. "Sets" are distinguished by twelve numbers or letters. There are, besides, the long and slender pins of hair-like wire, with which the entomologist fixes his insects on the cork bottom of his show cases; the staple-like double pin, "blued" or "blacked," plain or corrugated (also made by machines), used by ladies of the present day, to retain their natural or artificial hair in position; the safety pins used for dresses, the attachment of shawls, &c., or in the nursery, protecting the wearer from injury by being formed out of one piece of wire, bent so that the point, after passing through the folds of the dress, rests in a loop, which forms a sheath and thus prevents scratching. Of ordinary pins designated as Queen's own, imperial, lace, diamond, London, or London heavy, mixed or mourning, some are sold at 1*s.* 4*d.* per lb. imperial mixed, up to 2*s.* 2*d.* for small mixed, while the fine pins used by insect collectors fetch from 16*s.* to 112*s.* per lb.; if gilt, at 128*s.*, i. e. 7*s.* or 8*s.* per oz.! By whatever name called, they are only pins, valueless individually ("not worth a pin"), though in aggregate production they are important features in our national industries.

A calculation made forty years ago, stated that for home use and export purposes 20,000,000 of pins were required daily in England. The real quantity now produced daily is 50,000,000, of which Birmingham produces 37,000,000, leaving 13,000,000 as the production of London, Warrington, Stroud, and Dublin, where pins are also made. The weight of wire consumed annually in the pin manufacture of England is about 1275½ tons or 2,857,120 lb. (one-eighth of this is iron wire used in the manufacture of mourning and hair pins). The brass wire consumed amounts to 2,500,000 lb., which, at 11*d.* per pound in money value, reaches the sum of 114,583*l.* The iron wire consumed is 344,800 lb., its value 7183*l.* 6*s.* 6*d.*; and to be added to these amounts are the wages, paper, ornamental envelopes, boxes, wear and tear of machinery, manufacturer's profits, &c. Mourning, hair, entomological, and "papered" (i. e. stuck-in-row pins), realize a larger profit than pins sold by weight. Taking it altogether, the pin manufacture of the United Kingdom is not over estimated at the aggregate amount of 220,000*l.*

Pins are made in small quantities in France, Germany, and Austria, while in America the excellence of English pins was recognized as early as 1775; the Congress of America in that year offered a premium of 50*l.* for the first twenty-five dozen of domestic pins, equal to those imported from England. A limited success seems to have followed the premium until 1831, when Howe patented a machine for the manufacture of wire or spun-headed pins; and Slocum, who obtained in England in 1835 a patent for making a machine for the solid headed variety (eighteen years after Hunt, eleven years after Wright), worked his patent in America. Eventually the two companies working the Howe and Slocum patents were united, and they now form the American Pin Company. The weight of pins produced annually in America, allowing fifty working weeks in the year is stated to be from 350 to 500 tons per annum, or 1,120,000 lb., according to the most liberal estimate; and the value at 112,000*l.*, which, in comparison, is much in favour of the pin making of England, and demonstrates its importance as a national manufacture.

NEEDLES.

By the late W. C. Aitken (Birmingham).

The earliest remains of nations, whether uncivilized or civilized, bear evidence of the use of needles from different materials. In Egypt specimens of bronze three and a half inches in length are found; there were, no doubt, smaller examples, but these, in all probability, from oxidation, have perished in course of time. Bronze being easily worked, and the eye of the needle being readily drilled, probably suggested the use of the alloy for the purpose. Bone and ivory formed, and still form, the needles in use by the aborigines of other countries. In 1370 needles of steel were made at Nuremberg, where the skill of the craftsman was far in advance of those of other countries; and even at that period they had laid the foundation of their metallic industries, for they rolled iron and "latten," and drew wire in iron, steel, and brass. The fine steel wire from which wool cards were made in England, was imported from Germany; and long after the needle trade was introduced into England, the raw material of which they were made was sent from the former country. The early history of the manufacture of needles in England is unknown, and perhaps the idea that it would never become of much importance to a nation, accounts in part for the historical details being so meagre. At the present, however, the celebrity of English made needles, the number of hands employed, male and female, in the small towns and villages in Worcestershire and Warwickshire, more especially Redditch, Studley, and Alcester, entitles the manufacture to a place in a volume treating on 'British Manufacturing Industries.' Spain had once a reputation for its iron, and more particularly for its steel, and the Spanish alliance, in 1553 and 1558, in all probability had something to do with the coming of the Spanish Moor who lived, sold, and made (?) needles in Cheapside within the period named. The manufacture thereafter was located at Whitechapel, and hence the term "Whitechapel sharps" was applied to needles of a questionable quality. It has been stated that in 1543, needles similar to, though ruder than, those now in use, were made and sold in England, though every circumstance favours the idea that those used at first were imported. The Moor died, having refused to communicate the knowledge which he was supposed to possess, so that the art died with him. There is very much more probability in tracing the origin of the manufacture to Elias Crouse, a German, who, in 1667, taught Englishmen to make what were known as "Spanish" needles. Humphries, the "assay master" from Saxony, brought over Christopher Shutz, accompanied by twenty-two Saxon workmen, who were skilled in mollifying iron and steel, and drawing the same into wire. The wire of the latter metal is essential to the needle trade, which does not appear to have attained any importance till 1650, when an ancestor of the family of Milton (Mr. Damer) induced Christopher Greening, with three of his children, who was engaged in making needles in London, to settle at Long Crendon, in Buckinghamshire, where a needle manufactory on a small scale was begun, and indeed existed until very recently.

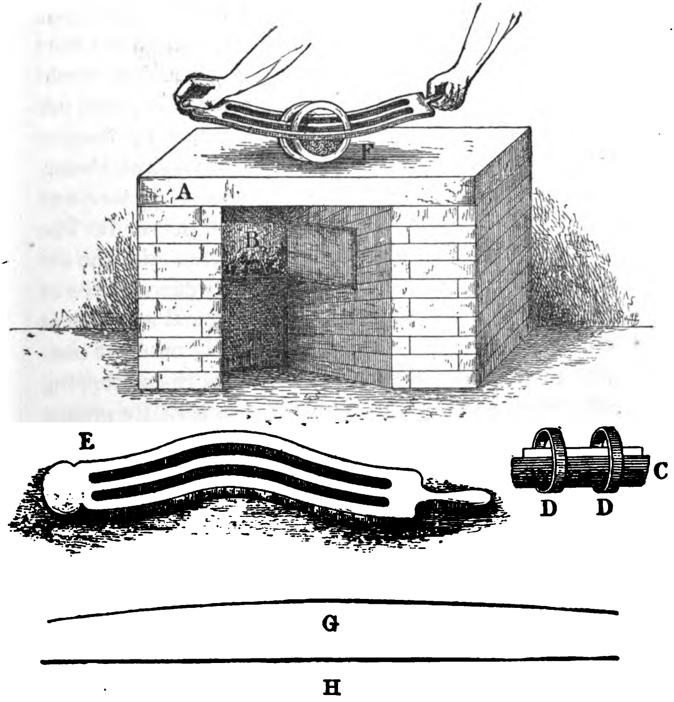
Needle making thence penetrated to Alcester, in Worcestershire, and from there to Studley and Redditch, and in another direction to Hathersage, in Derbyshire, though in none of these localities does there appear any peculiar fitness to have determined the localization of the manufacture, except that Worcestershire contained emery, largely used in grinding the points and scouring the needles. That which was in the beginning a "home trade," practised at home, or in small shops, by the needle-maker, has now almost ceased to be so, for the large manufacturers in the vicinity of Redditch are replete with every convenience and facility for conducting the manufacture. The most recent improvements are introduced for heating, ventilating, and getting rid of the baneful dust which rises from the wheel in the "pointing" operation, while horse-power, and the still more uncertain water-power, has given place to the steam engine.

There is this distinction between the manufacturer of pins and needles, that the former is generally his own wire-drawer, while the latter only exceptionally so, procuring his steel wire, drawn to gauges for the various sizes of needles, from those makers in Birmingham or Sheffield. On its quality, in connection with the skill with which the process of hardening and tempering are performed, the excellence of the finished needle depends.

In warehousing the wire, attention is paid that the store room in which it is kept is free from damp, or other influences likely to injure its quality. The bundles of wire weigh about 14 lb. each, the wire being in coils of 24 inches diameter; a smaller diameter, by increasing the curvature, would render more difficult the other process of straightening the lengths, to produce two needles, while the large diameter of the coil obviates the necessity for unwinding and rewinding, necessary under the old method of manufacture.

The cutting up of the bundle into pieces of wire, each sufficient to form two needles, is accomplished either by power, or by a workman with shears. If the latter, the shears are fixed in an upright position, the jaws being 8 inches in length, and the cutting jaws being removable for sharpening. Motion is given to the one jaw by the handle being left free, and to the first a gauge is attached to set the wire to the length required. The workman takes hold of the bundle of wire, applies it to the opened mouth of the shears, the free handle of which he presses with his thigh and cuts the bundle through, thrusting one cut end through the shears, and pressing it against the gauge to determine length, finally cutting the whole of the bundle up into lengths equal to two needles. Each bundle for the production of No. 6 needles is in length 1¼ mile, and from it 40,000 to 50,000 needles can be produced, though

THE "RUBBING" PROCESS.



A. Iron plate heated under by fire B. C. A number of lengths of wire to form two needles placed in the interior of two iron hoops DD; these drop through longitudinal slits in rubber E, which is then worked backwards and forwards with motion as represented by hand as shown at F. G. Wire as cut from bundle or coil. H. Wire after undergoing the process of rubbing.

their number is determined by the success with which the after processes are conducted.

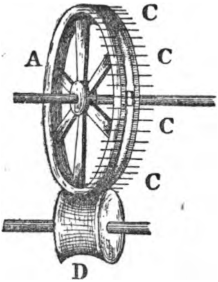
The operation of *straightening* or *rubbing* the cut-off lengths, all of which are curved (having been cut from coiled wire) by means of hammer or mallet, would involve a very considerable expenditure of time, nor could it be so successfully accomplished by simpler means than that adopted by the needle straightener. By this process each separate wire acts on another, and perfect straightness and parallelism are the result. The workman half fills two strong iron rings with the cut wires placed inside, and using a slightly curved piece of iron with two long slits cut through it, and a handle at each end, he lays the rings horizontally on a flat cast-iron plate, heated by a fire under it, the rings dropping into the slits in the convex curved iron bar. He presses on its handles, and, moving the rings with their contingency of wires in their interior, he presses on the latter at each end, where they protrude beyond the rings, and in the centre; after the operation has been continued for some time, the curved wires are straightened, and lie parallel to each other; every bit of curve has been got rid of, and every wire is "as straight as a die." (See cut on previous page.)

The next process is "pointing," or producing the sharp tapering point which distinguishes a needle. This is obtained by "dry grinding" on revolving gritstones, varying in diameter from 12 inches when worn, up to 20 inches when new. The grinder is seated in front of the stone, and picks up a number of the wires to be pointed with his left hand, retaining them with the points towards the stone. With the palm of his right hand he presses upon them, and applying them to the stone, causes them to rotate, or turn round horizontally between the palms of his hands, and the result is, long tapering points. The heat produced by the friction of the steel wire on the gritstone renders it necessary from time to time to cool the wires in water; and a brilliant stream of sparks follows the abrasion of the wire, together with particles of stone and steel very fatal to the needle-pointer, whose tenure of life is shortened from "grinders' asthma." The efforts made by humane and disinterested men to avert the effects of this "dry grinding" have been set at defiance, high wages, suffering, and comparatively early death being preferred by needle-pointers, to moderate wages, health, and a life as long as that of those engaged in other manufactures.

A prejudice existed against "pointing" by machinery at Redditch, as recently as the year 1844, at which time a pointing machine, invented by Mr. J. Chambers, was destroyed by the "pointers." German operatives engaged in the needle trade have no such narrow-minded prejudices, but use these machines; all their needles are so pointed, and it is one of the reasons which enables them to compete successfully with English needles in the markets all over the world. In Redditch, a German machine for the purpose may be seen at work in the British Needle Mill. The pointless wires, sliding down an inclined plane, drop on to and are held by a vulcanized rubber band, to the periphery of a metal wheel revolving in a right angular direction to a hollow grindstone, rotation being given to the wires by the hand of the grinder; the wires are held at the proper angle for pointing, and pass out with points nearly as perfect as the most prejudiced of hand-needle grinders could desire.

After "pointing," follows the stamping and the perforation of the "needle's eye." In the best class of needles it is customary to remove the scale from so much of the surface, in the centre between the two "points," as is to be operated upon by the dies, (which produce the indents of two needle-heads), end to end. The removal of the scale at the part named is done with small narrow grindstones by the "grinder." In the establishment alluded to, this is accomplished by a machine, also of German invention. This process in its arrangement is almost synonymous with that already described for "pointing," viz. a revolving wheel; the wires held on the periphery of the wheel by the vulcanized rubber band; the rotation of the

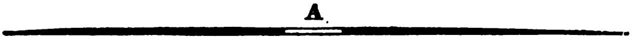
WHEEL AND GRINDSTONE OF NEEDLE-POINTING MACHINE, INVENTED IN GERMANY.



A. Revolving wheel to which needle wires CCCC are held by the vulcanized rubber band B, when they are carried round at the lower point of the wheel, they come in contact with the grindstone D, and are pointed. The wheel, A, revolves at a right angle to the grindstone, D.

wires on themselves, when they come in contact with the narrow grindstone, and the removal of the "scale."

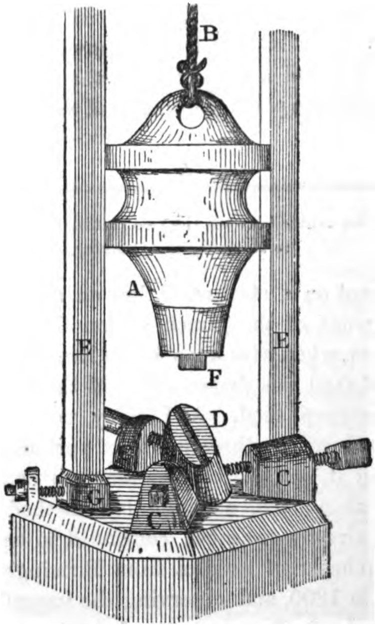
In the early stage of needle making, ere it reached the dignity of a manufacture, the eye end of the needle was simply flattened or beaten out with a hammer, and the eyes were produced by means of a small "punch" struck with a hammer. It required two operations. The head being laid on a small anvil, the punch was struck, and raised a convexity on the opposite side of the flat head; the position of the head was then reversed and laid, not on a steel anvil, but on a block of lead, and the point of the punch set on the mark of the former blow, when with a tap with a hammer, the minute particle of steel was driven out, and the perforation of the eye accomplished. A Studley needle-maker, in 1793, introduced another method of perforating the eye by drilling it, but the process was too expensive and therefore abandoned, and the old method of hand-punching already described continued to be practised. But a purchaser of needles from Birmingham visited Redditch in 1800, and observing the imperfect way of producing the hollow groove and perforating the eye, suggested the use of the "stamp" to impress the print of the groove, and the "press" with perforating punch to pierce the eye. These appliances are now universally employed in the needle trade.



Needle wire centre between the two points, ground previous to stamping the grooving.

The stamp has two uprights, and between these slides a "ram." To its under surface a die, cut in intaglio, with a representation of two needle heads, end to end, is attached, and another to the bottom or bed of

STAMP USED IN NEEDLE MAKING.



A. Ram or hammer.

B. Rope by which it is raised to hold lower die.

CCC. Snags and screw bolts.

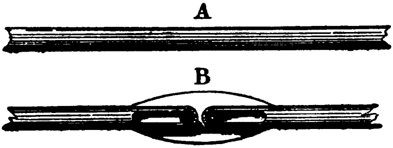
D. Lower die.

E E. Poppets in which ram or hammer slides.

F. Upper die.

G. Screws by which poppets are held.

the stamp, held by screws. The wire is laid in the lower die, a rope pulled by the needle stamper elevates the ram, the rope is released, the ram falls, and the die which it carries leaves its impress on the upper side of the wire, while the blow given has caused the wire to receive on the opposite side the impression in the lower die, on which it was laid. The perforation of the eyes is effected by the press, which has a screw operated on by a bent lever handle. Into a screwed hole at the lower end of the screw a punch is fitted,

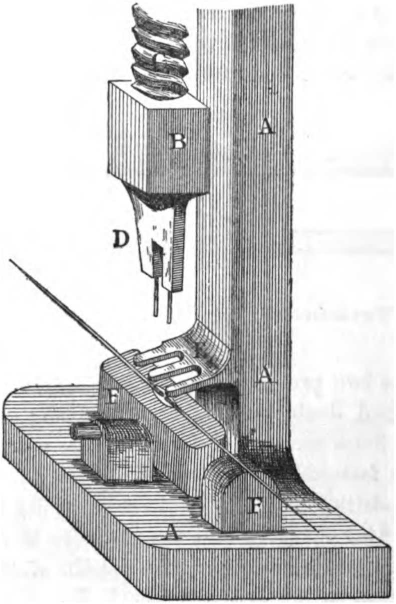


A. Wire before stamping. B. Result ot the stamp.

which has two prongs corresponding to the prints in the stamped double-headed needle blank; a bolster with two holes corresponding to the two points of the punch, is fastened to the bed of the press, and in a suitable pòsition immediately over it, is fixed a three pronged "taker off." The needle wire is laid in a "die print" in the bolster, the handle of the screw of the press is worked, the punch descends on and forces out the minute bits of metal indicated as prints for perforation, in the stamped double-headed needle wire; and on the return of the punch, should there be any difficulty in withdrawing it from the perforated wire or needle, the "taker off" assists in setting it free.

The wire now presents the appearance of two needles joined head to head, but the superfluous metal or "flases" have to be got rid of; two wires are

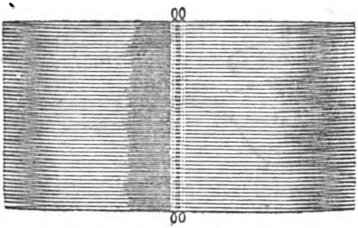
PRESS USED TO PERFORATE EYES OF NEEDLES.



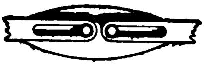
A A A. Frame of press.
B. Box for attachment of punch. C. Screw.
D. Double punch.

E. Bolster with two holes corresponding to punch.
F F. Studs with screws to hold bolster.

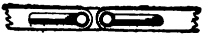
threaded (technically "spitted") through the eyes of about one hundred needles, until the arrangement presents the appearance of a fine toothed double-sided nursery comb. The needles so "spitted" are laid flat on the work bench, and a few sweeps of a flat smooth file remove the surplus metal. The minute marking at the junction of the two needle heads assists their separation; the strip is bent in its length, and two rows of single independent rollers are the result. One row of the needles, still held together by the spit, is placed in a wide-mouthed plier-like tool, and a sweep of a file removes the roughness of the needle head, where it was separated from its former companion. Another file-sweep removes the sharp angular corners



Needles "spitted" together for removing fins caused by stamping.

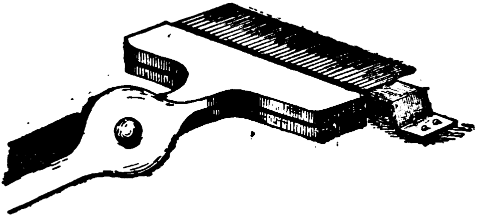


Before spitting.

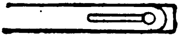


After spitting.

from the head; the spits are now withdrawn from the "eyes," and the needles are independent of each other.



Row of single needles held in plyers for removing roughness left on separation at heads.



Broken off and before filing.

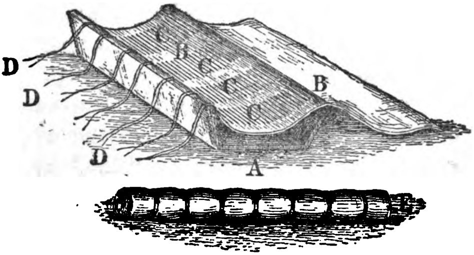
The needles which may have been bent in these operations are next-straightened by the pressure of a flat convex bar operating or pressed down on them, as they are made to rotate on the surface of a "trued" metal plate, exactly on the same principle as the straightening of the lines in the first operation, i.e. pressure under rotation.

The qualities of elasticity and rigidity have yet to be imparted to the needles, and for this purpose they are conveyed to the shop of the "hardener" and "temperer," which is fitted up with muffles, or small furnaces with arched doors, fitted with bars in their interior on which to rest the trays on which the needles are arranged. The trays are formed of sheet iron bent up at each end, and with a flange at right angles, by which to hold them for their introduction into and withdrawal from the muffle. The needles are arranged in rows many deep across the trays, which when filled are placed on the bar in the muffle; the door is closed, the fire underneath speedily heats the trays and their contents, the "redness" of the needles being determined by the "hardener's" knowledge, generally gained only by practice and experience. At the proper heat the trays are withdrawn from the muffle, and their contents emptied into a cistern filled with oil and fitted with a lining with a perforated bottom, which retains the needles and permits the oil to find its way again into the cistern. The surplus oil is got rid of by shaking the needles in sawdust, after which they are replaced on the trays, and again put into the muffle, though at a much lower temperature. The effect of the heat on the needles is carefully watched, and on their assuming a light or dark straw colour, as the nature of the steel requires, the trays are withdrawn, the needles allowed to cool, and they are now considered "tempered." The test of the excellence of their temper, the quality of the steel, and the skill of the hardener and temperer is as follows: if on trying to bend a needle, it neither breaks, nor remains bent after the removal of the test pressure, its quality may be relied upon; if the needle breaks, it is too hard, and if it bends, it is too soft.

It has been remarked that in hardening, the red-hot needles which were immersed in oil remained straight; but when immersed in water, a very considerable proportion were found to be bent. A class of needle workers was engaged in an operation called "hard straightening," and in consequence realized good wages by making the crooked straight; but by substituting oil for water, crooked needles have become the exception, and hard straightening became exceptional. The inventor and reviver of the oil hardening process shared the fate of most inventors in this trade, and was driven away from Redditch by the abuse heaped upon him. Thus it has ever fared with improvers of industrial processes in times gone by—as witness the Jacquards, Cromptons, Chambers, &c., though it is satisfactory to learn that increasing knowledge and the demands of manufacture have dissipated prejudices, and oil hardening is now generally adopted. The process of straightening needles hardened in water consisted in tapping the bent needle with a small hammer, as it lay on a flat steel anvil.

After hardening and tempering the needles, the appearance that they present is a black blue, with a shade of straw colour or "glance." The blackness or scale has to be got rid of, and the needles made bright, smooth, and clear, and this is the result of the process of scouring, which is accomplished by the friction of thousands of needles rolling against each other, aided by a mixture of oil, emery, and soft soap, distributed among the needles bound up in envelopes of canvas, and subjected to the pressure of a platen. The machine of which it forms a part is set in motion by steam power; the preparation of the needles for scouring consists in placing a strong piece of canvas on a wooden tray, under which strings are laid, and on it the needles, heads and points indiscriminately, but parallel with each other, and with many rows in the breadth. The mixture above described is distributed on the surface of the needles, the canvas is then rolled up, is firmly bound together with the strings, and laid with others on the bed of the scouring machine. The movable platen is then placed over them and the machine is set to work, the mangle-like motion of the platen causing the bundles to roll over and over, so that each individual needle revolves against another, producing abrasion. The friction

MAKING UP NEEDLES FOR SCOURING.

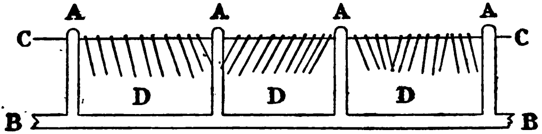


A. Wooden tray. B B. Canvas cover.
C C C. Canvas cover on which needles are laid.
D D D. Strings with which to make up bundle.
E. Bundle made up for scouring.

generates heat, and at this point some attention is required, for the temper of the needle is at peril; at 300° no change takes place in it, but at 400° the "mildest" steel needle-wire is affected, and the operation of scouring is therefore suspended (usually at the end of eight hours) that the needles may be kept cool. The bundles are then withdrawn from the machine, opened, the needles separated and washed in an alkaline solution of soap and water, then dried in a shaking barrel filled with sawdust, after which they are again arranged in the manner already described on a new canvas cover, though with a change of mixture. The emery is taken away, and oxide of tin (the "putty powder" of the workshop) is substituted for it, in order to "fine" or polish the needle. "Scouring" and "fining" are accomplished after five or six times of eight hours length each. The English method is not the same as that of the Germans, who say that they are able to scour and fine in forty hours a greater number of needles than is accomplished by the process just described; they also avoid the heating of the needles and the reduction of their temper.

The needles are now unloosed from their canvas cover, and subjected for the last time to the action of the alkaline solution, dried in sawdust in the shaking barrel and then conveyed to the "bright shop," where they are examined, the defective ones being picked out, and the perfect ones arranged on tin trays, to which motion is given by hand, so that the needles arrange themselves parallel to each other across the tray. The heads and points, however, present themselves indiscriminately on each side of the row, and a process follows, in which the aid of a simple tool (a cloth finger stool) on the forefinger of the left hand of the "header" (as the female is called in the trade) is called into operation. She selects a number of needles, and with the right hand presses them against the cloth-covered forefinger of the left, into which the points stick and are withdrawn, as the heads of the needles being blunt do not adhere. Babbage selects this as an example, where, by means of the simplest tool, operations which involve time may be facilitated and time saved. Selecting needles singly out of a great number or heap would involve a considerable expenditure of time, but the use of the cloth finger stool enables the header to draw out from six to twelve by one operation. The further reduction of the temper is necessary to aid in polishing the interior, and removing any roughness or sharp edges likely to cut or "fray" the thread. This is done by arranging a number of needles on a square iron bar three or four inches thick, allowing so much of the eye end of the needle to project over the edge as requires to be softened. The needles are retained in position by another piece of iron laid over them, and a bar with a handle attached is then heated and drawn along the perpendicular face of the block, *under* the needles, so that the heated bar parts with a portion of its heat, and the temper of the eye end is "softened" to aid in the after process of polishing the interior. This crude process is far inferior to the more intelligent method adopted by the German needle-makers, who accomplish the softening of the eye end by a flame of gas, with a revolving metal wheel and a vulcanized rubber band to retain the needles in position. The circumference of the wheel has on its surface a series of transverse slits cut at equal distances, each sufficient to accommodate one needle. The wheel is fed from a hopper, a needle dropping into each slit as it presents itself to be filled; the head end of the needle projects, the wheel revolves at a uniform speed, and carries it through a gas flame, the progress being so timed, as to reduce the temper of the eye end of the needle just as much as is required, and no more. At a given time the softened needles drop out into a receptacle prepared for them.

The softening process finished, the polishing of the interior of the eye follows, this being the *pons asinorum* of the needle manufacturer. Attention has already been directed to the Studley maker who drilled the eyes of his needles, and then polished the interior by means of a "rimer" revolving in a lathe, on which he worked the interior of the needle eye. This was attempted by a prior inventor in 1775 and 1789, by using very small revolving discs of two sizes, the larger of which ground the "guttering" of the eye, while the smaller polished it. "Drilled eyed needles" are now a myth. The process, until recently, for best needles was carried out by the small rimer (revolving in a lathe) which, passing through the eye of the needle, worked in all directions, smoothing, fining and polishing the eye. In 1839, however, a Redditch needle manufacturer, Mr. Abel Morrall, invented a simple method by which thousands of needle eyes can be polished simultaneously. A platform, on which a number of uprights are erected, has imparted to it by power a backward and forward shaky motion, and between every two of the uprights are suspended wires of steel, made rough by means of a file pressed firmly upon their diameter. As they rotate under its pressure on the work bench, the needles are threaded on the wires, and move about on it freely; the wires are then suspended from upright to upright, motion is communicated to the platform, and a pendulum-like motion is thereby imparted to the needles, the polishing of the interior of the eye being assisted by the wires being lubricated with a little oil and very fine emery powder, or oxide of tin.



A A A A. Upright erected on platform.

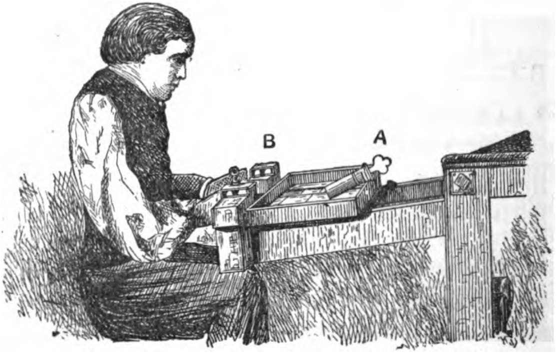
B B. Moved in longitudinal direction, and a shaking motion given it.

C C. Roughened steel wire on which needles

D D D are suspended by their eyes.

This process being concluded, the needles are next conveyed to the head grinding and "colouring" or "fine" polishing shop. The former is done by small revolving grindstones, against which the head is held and rapidly worked, until all the little angularities are taken away. The final polish is accomplished by revolving cylindrical pieces of wood of small diameter covered with thin buff leather, technically called "bobs." They revolve with very great rapidity, frequently at the rate of from 2500 to 3000 revolutions per minute; the "bolt" being placed in the head or rest in which it revolves, the "gut" band is lodged in one of its three speeds, and the buff leather is sprinkled with "putty powder;" the polisher then picks up a dozen needles, presses them lightly against the "bob," causing them to rotate in his hand, and thus polishes the heads; then, reversing their position, he polishes the point, and finally, presenting the needle lengthways, it is polished longitudinally. The rapidity with which

NEEDLE POLISHER (LAST OPERATION) AT WORK.



A. The polishing "bob."
B. The rest or "head" into which it drops and works.

this is effected is shown, by a good workman being able to polish a thousand needles per hour.

The last operation completes the making of a needle; what follows is confined to the warehousing, the counting, and wrapping them up. The paper selected is a dark slate colour, and is dried carefully (damp would rust and injure the brilliant polish of the needles) and then cut into the proper sizes by means of a bookbinder's guillotine knife, a great number of sheets at a time. The folding is done by two rolling machines, one of which determines the length of the "envelope," the other its breadth; and a clever wrapper-up (generally a woman) can count and wrap up 120 papers containing twenty-five needles each, in all 3000, in the brief space of one hour. Boys paste and attach the small labels, which bear the number of the needle, manufacturer's name, or that of the retail dealer. The small packets (when for exportation) are made up into larger packets (in dried papers) and contain frequently ten, twenty, or even fifty thousand needles, these packets being packed into tin boxes and hermetically soldered. A recently introduced feature in the needle trade is the sale of packets of needles in ornamental cases of brass of various devices. Some of these elevate the needles on being opened, by simple ingenious mechanical arrangements, which, on closing, withdraw them into its interior. The cases, however, not being made by the needle maker (though an adjunct to their trade), do not call for further notice.

The quantity of needles produced annually in England is immense. They embrace every variety, size, and number used by the lady in embroidery, crochet, and netting, by housewives in their homely sewing, and by the male sex as tailors, saddlers, shoemakers, glovers, sail-makers, and packers. The advent of sewing machines, while it has created a speciality in needle making, does not appear to have decreased the demand for ordinary needles. During the Franco-German war, needles were made for the gun which bears the prefix of the domestic instrument, i. e. the needle gun, and great quantities were required by the surgeons engaged in the merciful duty of "binding up wounds." The surgical needle, though made by needle makers, is a curved needle, having the point sharp, and four-fifths of the length thin and flat; they are made of various lengths, the longest of which are used after amputations, the next for ordinary flesh wounds, the shortest for sutures. The delicate purposes to which these needles are applied, the necessity which exists for sparing unnecessary pain to the patient requires them to be made by hand, with the greatest possible care, and each ground and polished separately.

There is probably no manufacture which illustrates the division of labour more completely than that of needles, and not one in which simple operations tend to such successful results, or in which prejudice has operated so potently in preventing the application of machinery, or the adoption of really simple, useful, and economical processes. Humanity and increased intelligence demand that the process of dry grinding should be put an end to, and there are others which can be performed in a more scientific manner, such as hardening and tempering. Even the softening of the needle's eye, as ordinarily conducted, is discreditable to the needle trade.

The hands employed in 1861 were a little over 4000, but at the present period (1874) they have increased to upwards of 4700; the location of these shows the seat of the needle manufacture to be Worcestershire and Warwickshire, in the former of which counties 861 males and 897 females were employed; in the latter, 1108 males and 1758 females, an aggregate of 4275 workpeople, as opposed to 454 distributed over other counties, principally in Leicestershire, Nottinghamshire, &c.

The social condition of the workpeople residing in the small towns of Redditch, Alcester, and Studley, and in their immediate vicinity, is equal to those engaged in other manufactures practised under similar conditions. The wages under these circumstances range from 1*s.* 6*d.* to 5*s.* per week for children, females from 8*s.* to 15*s.*, and males from 12*s.* to 40*s.*, though the last-named sum may be taken as exceptional.

In the needle trade certain curiosities are to be found, such as double needles for seamstresses troubled with imperfect sight, where the eye is made to open at one side to facilitate easy threading; magnetized needles and thimbles, to prevent the needle being lost; needles, the eye of which is wider in the direction of the point of the needle, or with a double eye, to hold the thread firmly; needles made with a swell in the middle, tapering towards point and head, to facilitate the easy passage through the cloth. A project was patented for dispensing with "dry grinding" by "suspending the needles to be pointed to the positive pole of a galvanic battery, immediately above the negative element, and as close as possible to it without being actually in contact, some exciting liquor, as dilute nitric acid, completing the circuit."

SADDLERY.

By the late W. C. Aitken (Birmingham).

Saddlery is an important branch of national industry, which is in extensive demand for home consumption, and figures largely as an article of export to other countries. The greatest quantity is sent to Australia, South Africa, and British India, though other countries also consume English made saddlery. Viewed in relation to the number of workmen, &c., employed in labour in this country, saddlery absorbs the labour of not fewer than 22,000 individuals, and in this particular the saddlery manufacture ranks high among English trades.

Though every town and important village in this country has its saddler, its chief seats (though considerable quantities are made in London) are the towns of Birmingham and Walsall, in both of which very large well-conducted manufactories exist, exclusively engaged in the production of these articles. As early as the end of the thirteenth century, these places were celebrated for the quality and quantity of their leather: leather, it is almost unnecessary to remark, being the raw material from which saddles are made. At an equally early period, the inhabitants of these districts were also famous for their skill in working in metal.

Specialities in metal enter very extensively into saddle work, more especially into the harness department. The production of metal work employs a very large number of workmen, the trade embracing bits, spurs, and stirrups in iron and steel, the metal mountings of harness, buckles of various kinds made of iron plated* with silver or brass, covered with leather, or of solid brass, "terrets" through which the driving reins pass, armorial bearings, as coats-of-arms, crests, and other ornaments used for the enrichment or decoration of carriages. These latter are produced from thin sheets of silver or brass by means of stamps and dies, strengthened by "filling" with soft solder formed of lead and tin. Other plainer and more substantial ornaments, used in the harness of drays, waggons, and carts, where wear and tear render substantiality necessary, are also produced in great quantities, by workmen in saddlers' ironmongery. These workmen, it may be observed, are not included in the number given as employed in the saddlery trade.

There are two classes of operative manufacture in the saddlery, one of which is known as the "brown," employed in saddles, bridles, and articles of uncoloured leather; the other is engaged in the production of ornamental harness for carriages, gigs, &c., and also the more practically useful harness used for traction, agricultural purposes, &c., and made out of leather stained black, whether "patent" or otherwise.

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* By the expression "plated" is not meant coated by means of electro deposition, but thin sheet metal made to assume the appearance of a "shell," tinned inside with soft solder, and made to adhere to the foundation or core of iron or steel by fusing the solder.

The processes of tanning the leather for the manufacture of saddlery will be found in another volume,* and it is therefore unnecessary to say more than that the leather used in saddlery is made from the hides of cattle and horses, imported from South America. The "calf" skins and "kips" (the latter taken from half-grown cattle), in their raw state are chiefly supplied from the Continent, while the "pig" skins, almost exclusively used for saddles, to form the "seats," on account of their elasticity and wearing qualities, are imported from Scotland, these being superior to the skins of .pigs from other countries in durability and beauty of colour. Attention may here be directed to the very successful imitations of pig skin, by means of copies from a hardened or prepared pig skin, which is produced by the trough of an electro depositor; the plate gives a perfect copy of every bristle-mark and irregularity of the skin. All that is necessary is, simply to lay the copperplate on the table of a press, and over it, the smooth leather to be impressed, which is then passed through rolls, and presents an exact imitation of pig skin, difficult of detection by the uninitiated. For the "seats" of saddles this imitation is not suited, but it is used for those portions known as the "skirts" and "flaps," which in best saddles are covered with real pig skin. Formerly the granular appearance on the surface of these portions of the saddle was produced by means of the hardened, dried, and stretched skin of a shark, pressure being required as just described.

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* 'British Manufacturing Industries,' "Hides and Leather," page 33.

The chief object in brown saddlery is to make a good saddle, consisting of a skeleton, or "tree," a "seat," "skirts," and "flaps." The tree is generally made of beech wood, strengthened with iron plates, though iron is sometimes used alone. Sheet iron is sometimes used, and other materials have also been recommended, but beech wood tree holds its own. Next comes the means of attachment of the stirrup leathers, now known as "spring bars," which permit of the easy release of the stirrup leathers in case of accident. The *modus operandi* in saddles consists in nailing on from the "head" to the "cantle" two lengths of strong girth webbing, to secure convexity and elasticity of the seat, while other lengths of webbing are nailed across. Improvements in the construction of the foundation of the "seat" have been introduced by the application of other materials as vulcanized rubber, catgut strings, coiled springs, &c. The preparation of the foundation of the seat for its covering of hog skin having been completed, that of the "skirts" and "flaps" follows, these being of cowhide leather of medium thickness and good quality. Great attention is paid to the size of these parts, so as to fit them correctly. The commoner leather or basil which forms the "pannel," and serves to contain the padding retained by the inner lining of serge (which is cut larger than the "basil") is sewn together by women. Two "bellies," formed of leather, "thinned" and stuffed with doe hair, are nailed one on each side of the "tree," to give the seat the required breadth and shape. The so far advanced seat is now covered with serge, and the stuffing, which gives elasticity and softness to the seat, is introduced through a slit in the serge cover, by means of a thin steel tool called a "seat-iron," and by it is distributed over the seat under the serge. The "tree" is now in a condition to receive its covering of hog skin, which is damped on its under side, and temporarily fitted on; at this stage the skirts and flaps are also fitted, the seat being marked where the flaps come; the "pig skin" is next removed from its temporary "fixings" and given to the "seamer" to join the seat to the "skirts." The "pannel" is then stuffed with wool, and quilted to secure its shape and firmness; and the seat covering, slightly damped, with the skirts attached, is finally drawn on to the seat to the position which it temporarily occupied. The skirts and girth straps are next attached, and the pannel nailed on, completing the manufacture of a saddle of the best quality.

Allusion has been made to sewing together the parts of leather forming a saddle by hand labour, but in saddles, as regards stitching done by machinery, as for example, where the saddle-seat, &c., is covered with ornament, the flaps and skirts have each also their rows of sewing better and more speedily accomplished by means of the now universal sewing machine, which is largely taken advantage of by manufacturers of saddlery. The leather, with the design to be sewn "pricked" on, is turned in every direction by the machinist, the needle supplied from the reel with its orange, or other coloured silk thread, following the sinuosities of the curves, leaves, and flowers in the design.

Whether saddles should be made light or heavy, long or short, and what the construction of the seats before covering should be, taste, durability, and the market for which they are made, will determine. Racing saddles are the lightest made (many of these do not weigh more than 2 lb.), those for military service are the heaviest, while ordinary saddles vary in weight from 9 to 13 lb. The varieties of saddles made in addition to those named, are "side" and "pilch." In military saddles (especially "Hussar") the "head" and "cantle" are more elevated, the seat more concave, than saddles generally used by civilians.

Bridles form an important element in the "brown" saddlery; they consist of parts designated "the head," "bit cheeks," front, nose-band, throat-lash, and reins. To the reins the bits are attached, the latter being made and supplied by the "saddler's ironmonger," so that the actual labour of the saddler in the making of a bridle is small. The "front," which is generally ornamented, is seldom the work of the saddler, his part being confined to the attachment of the buckles and the "keeper," to retain the superfluous length of strap after passing it through the buckle. The various straps which form the bridle are cut with what is called a "cutting gauge," made of iron, and consisting of a square iron bar, into one extremity of which a cutting blade is fitted. The bar is marked with a scale to distinguish the breadth of the straps to be cut, and, on the bar slides, a piece of thick iron, with its perpendicular and horizontal faces dead true and accurate. This iron, when set, is held fast by means of a screwed thumb-bit. To form a strap of the required breadth, the skin is cut straight on the edge, the workman applying the cutting gauge and pressing the surface of the guide against the leather, so that he can cut with unerring accuracy numerous strips or straps of the breadth required.

Black saddlery embraces the production of harness of every kind used on horses for drawing carriages, chariots, and gigs. It also includes harness for the artillery and transport military service, together with mule harness, for exportation. The raw material is still leather, with its natural colour changed by the application of japan or varnish, and then called "patent." This is applied in the parts of the harness, as the blinkers, covering of the collar, the saddle, &c., where ornament is desired, strength not required, and strain not likely to occur. The coating of varnish is superficial, and, though tough, it cracks on being subjected to strain. In harness making, the manipulation is identical with that employed by the "brown" saddler. The straps are cut by the cutting gauge, while other parts of leather, formerly cut by means of a sharp pointed knife following the outline of a model or template, are now operated on with a "punch" laid on the leather and placed under the platen of a press. In black saddlery, the application of the sewing machine is even more general than in the brown, and may be said to do all the stitching, plain and ornamental, save those parts which, it may be safely said, will never be accomplished by the machine. A notable example of the rapidity with which work is done by the machine, is presented in the making of "traces." These consist of two or more thicknesses of leather united together by string; a trace throughout its entire length is firmly sewn by the machine in as many minutes as it formerly consumed hours, if done by hand labour. Again, the round edge of the trace (formerly produced by "spokesheafs" used by hand), is now accomplished by means of the revolution of two concave cutters, through which the trace, the edge of which is to be rounded, is rapidly passed. The subdivision of labour, the improvement in tools, and the application of machinery, have very largely operated, more particularly within the last few years, in quickening production, and providing for the increased demand for saddlery for the purposes of export. It may be added, that if the saddler's ironmonger by his productions aids the "brown," in a very much more important manner does he aid the "black," or harness maker, for the latter is dependent on him for the great variety of parts in metal, which are essentials in this department.

The productions of the manufacturer of saddlery include an almost innumerable variety of articles in leather, whether brown or black, not named among those already described; such as holsters, valises, magazines for holding cartridges, saddle bags, sailors' belts and "palms," used by sailors in sailmaking and repairing. For travelling purposes there are portmanteaus, railway travelling bags, letter bags, cash boxes, school-boys' and other satchels, and dog collars, with or without brass inscription plates. In solid leather, gun-cases, strong, light, and portable; powder flasks, dram bottles of glass, ingeniously protected; shot belts, leggings for riding or walking, and cigar, cigarette, and fusee cases, all enter into the productions of the saddler, together with straps in an immense variety, for holding plaids, rugs, or coats, saddle cloths, girths, and horse clothing. Though whip making is practised apart from saddlery, as a separate branch of industry, many of the large manufacturers of saddlery also manufacture whips of all kinds, and for all purposes.

Where soundness of material and durability are required in the articles exported to foreign countries, English saddlery is preferred; where ornamentation, embroidery, and colour, is demanded, that of France enters successfully into competition; but even in the face of the latter, the soundness, practical usefulness, and enduring qualities of our home trade are becoming more and more generally recognized; and as a consequence the export is steadily and annually increasing.

The workpeople employed in the manufacture of saddlery are stated by one of the largest manufacturers in the trade, to be, as a rule, steady, respectable, and thrifty. The proportion of women employed (1830) does not reach one-twelfth of the males (21,181). For wages, the "bridle cutter" gets from 20*s.* to 30*s.*, the harness maker, 30*s.* to 40*s.* The highest paid are the workmen employed in the production of saddles of the best quality, who get from 30*s.* to 45*s.* Women earn, on an average, 10*s.* per week; superior hands, who can attend to and execute their work in the sewing machine, earn 15*s.*

An allusion has been made to the export of saddlery, which is shown to be steadily increasing, by reference to the Government returns extending over five years, though it should be remembered that in 1871 the Franco-German war materially increased the exports of saddlery.

ELECTROPLATE.

By the late W. C. Aitken (Birmingham).

Electroplate has now entirely superseded the silver-plated ware, which, some forty or fifty years ago, was the only substitute for articles made entirely of silver. The advantage of plated wares being cheaper than those made of silver, was met by the disadvantage, that the plated article showed, after a very few years' wear, the copper on which the silver was laid. Unquestionably the discovery that a thin plate of silver could be soldered to a thicker bar of copper, and that by rolling, the two metals would adhere to each other, as the bar was extended under the action of the rolls, was a great discovery, as it enabled those of limited means to possess objects apparently of solid silver, which were not so.

It was impossible in the manufacture of wares in plated copper, to produce details with any approximation to sharpness. If stamps and dies were used, the results were tame and unsatisfactory, and to secure this sharpness, the thickness of the epidermis of silver on the copper would have been so diminished, as not to be able to resist the cleansing necessary from time to time. If the parts had been cast instead of being stamped, they could not have been plated, for no known process then in existence could have accomplished it, so that in all such objects as salvers, covers, or dishes on which meat was served up, the "gadroon" or other pattern edgings or borders were stamped out of very thin sheet silver, and filled in afterwards, in order to strengthen them, with lead solder, which, like the copper, speedily showed itself. The conditions necessary for working up the material exercised a deteriorating influence on the forms, and hence the uniform tameness and want of spirit which, in a marked degree, characterized all objects executed or produced in copper plated with silver by means of rolling.

It is necessary to make these remarks, in order that the more recent processes introduced into the manufacture of electroplated articles may be more clearly understood. For copper, which is red and soft, is substituted German silver, which is hard and white, being an alloy composed of copper, zinc, and nickel; and when these metals are completely mixed, the contents of the crucible are poured into iron moulds, and produce "strips" of various lengths, breadths, and thickness. These strips, having the end at which they were poured cut off, are then subjected to the action of the rolling mill, in which process the metal becomes hard, its ductility being restored from time to time by annealing in a muffle furnace. Having been reduced in thickness to the required gauge, the sheets of German silver are then cut up into the size corresponding to the object to be produced. Globular "bodies," dishes, vases, &c., are produced or "raised" by hammering, "beating-up," "spinning," or stamping in dies; ornaments, handles, and feet are stamped in dies, or are cast from carefully-chased permanent metal patterns in German silver, and after casting they are repaired and chased before being affixed to "body," &c., of which they form a useful, or integral part. They are not fixed by means of *soft*, but with *hard* solder, which necessitates that the respective surfaces be made red hot, that the solder may fuse, and unite the parts. This differs from the soldering adopted in the old plated wares, union of parts in these being accomplished by means of *soft* solder, which melts with the heat of the tinman's copper bolt or "doctor." This style of union was very apparent in a plated candlestick, when the candle burnt down into the socket and melted the solder, or in teapots which, when not quite full, were left in too close proximity to the fire, so that the spouts dropped off, and the handles became disconnected.

By the electro-metallurgical process of coating or plating with silver, every part of an object is plated *after* it is fitted together, whereas in the wares made out of plated copper, they were plated *before*, so that, in the putting together, the trimming of parts at their junction reduced the thickness of the silver, and at these junctions the copper became soonest apparent. The density of the silver on the copper, as compared with that deposited by the electro-metallurgical modern process, has been disputed, but the articles plated in the vat of the depositor wear better and longer than those produced in the days when all plated goods, whether made in Sheffield or Birmingham, were of copper plated with silver. Electroplate alone is to be found in all establishments such as hotels, restaurants, &c., where hard wear and rough usage are the rule, while articles of an ornamental character in electroplate are preferred, owing to their better taste and superior design, united with economy of cost. The old plated wares, when partially deprived of their silver, had to be thrown into the lumber room or sold for old copper—they could not then be replated; but modern electro-metallurgy has supplied the means by which they could have been. The old mode contrasts in every way unfavourably with the new, the special qualities of which consist in the greater application of artistic power in the designs to be worked out, and the more enduring qualities of the objects produced.

I have already stated the composition of German silver, and how it is cast and rolled. Forks, spoons, and articles of that class are made from thick sheets of this material, cut out into "blanks" by punches, and corresponding "bolsters" of steel, worked in presses moved by hand or machinery. The punch in its form is exactly that of the outline of the spoon or fork; the details of ornamentation on the handle, whether "fiddle" or other pattern, and the concavity of the mouth of the spoon and its sweep, being produced in dies by stamping with repeated blows of the hammer or "ram" of the stamp, to which the counterpart of the die is attached. The prongs of forks are cut out also by punches and beds. Articles of a globular form, and others of a similar kind, as the "bodies," tea and coffee pots, and other vessels connected with dinner and tea services are "raised up" from flat sheet metal by skilful hammering; others are produced by "spinning," a process which consists in converting a flat disc of metal, revolving in a lathe, and held against a block of wood by the pressure of another piece, to hold the metal against the "chuck" in the spindle head of the lathe. When the lathe is set in motion, the disc of metal revolves, the outer circumference of the disc being pressed against with a blunt long-handled steel "burnisher," while additional pressure is gained by an iron pin which drops into a hole or holes in the "rest" of the lathe to serve as a fulcrum, the tool representing the lever. The flat disc of metal becomes concave, and is converted into a globular or part of a globular form, and, as in rolling and stamping, the metal in spinning requires to be annealed to restore its ductility.

The process of stamping is also taken advantage of very extensively in the production of electroplated articles, such as "bodies" of spherical and other forms, especially where "fluted" or covered with foliated ornaments; the "feet" and handles, when not cast, are also produced by stamping; and here again the raw material used is thin rolled German silver. Dies, steel-faced, or steel laid upon iron, called "fullered," are used, and the design to be reproduced is cut, incised, or sculptured in intaglio. The die is held firmly to the bed of the stamp by means of four screws, and to the fulling hammer of the stamp, which slides between two upright rods of metal (i.e. the poppets of the stamp) is attached a convex copy of the design sunk into the die, which is frequently changed. The first succession of "forces" simply serves to give convexity, succeeding "forces," more developed, giving the details of the ornament, until the last one brings up every detail of the design in the die. It is almost unnecessary here to add, that when the flat disc of metal is sunk to the depth of the "force," it is annealed in muffles, or oven-like furnaces, in which the flame from the fuel plays on the roof, the metal being as far as possible from the oxides which are frequently associated with the carbon of the coal.

Where portions of articles are cast in German silver, and economy in production precludes the application of hand-labour in "chasing" and "repairing," dies are used in order to give additional sharpness.

It will at once be understood, from the facts already given, that the production of articles of electroplate in parts necessitates their being put together; and where the parts are not held together by screws and nuts—as the handles of dish covers, cruet stands, knobs of tea and coffee pots—it is requisite that they should be firmly held to the object, as "feet," handles and spouts of tea and coffee pots, &c. It is a distinguishing feature of the electroplate manufacture, that the portions of the object to be permanently attached are done so by means of *hard* solder, and in order to accomplish this, they are first carefully fitted to the "body," and held there by means of binding wire of iron, or clips. At the places to be united, ground borax and solder are laid, and in order that no heat may be lost, the object to be soldered is placed on an iron tray, on which coke is distributed. The heat necessary to melt the solder is produced by gas, supplied through the instrumentality of an autogenous blowpipe or double tube, the outer tube conveying the gas, and the interior a blast of air, which, uniting with the gas immediately before it issues from the orifice of the blowpipe, increases the size of the flame, and also its heating power. Change in the direction of the flame to any portion of the object to be soldered, is accomplished by the mouthpiece being attached to a flexible indiarubber tube. By this means the workman directs the flame, so as to play upon the surface of the article, which speedily assumes a red heat, its chief force being directed to the parts to be united. The borax melts into a transparent glass, the solder fuses, and the parts formerly twain become one, and are so firmly attached, that any attempt to separate them would only result in tearing away the metal.

The borax which is left after the soldering is got rid of by "pickling" in a diluted solution of sulphuric acid, after which the articles are rinsed in water and dried in sawdust, to be passed on to the "trimmer up," who, by specially formed files, removes the superfluous solder. The goods are next placed in the hands of the polisher, who, with "buffs" and "brushes" revolving by steam power, polishes or renders smooth every part of the surface, abrasion being promoted by Trent sand, or powdered Bath brick.

Where the objects require engraving or a simple development of the repousser's art, they are next sent into the engraving shop, where the artist, having traced the design with a sharp steel point, with his graver cuts it indelibly on the surface. If the article is globular, by means of bent tools, called "stakes," he forces up, by striking the opposite end of the stake with a hammer, the projections on the exterior surface. If the object is a salver, he strikes up elevations on the side to be exposed. The globular vessel is filled with pitch, but if it is a salver, it is placed on a pitch-covered block of cast metal or wood; the outline of the ornamentation is traced and formed with small blunt chisel-pointed tools or "tracers." Then follow the details by means of chasing or "matting," which give the various textures that impart variety to the ornamentation.

The roughness consequent on the action of the "graver" having been smoothed down, grease or objectionable matter is removed from the surface of the object to be coated, by placing it in a boiling alkaline solution of pearl-ash or soda, rinsing in cold water, and drying in sawdust, and it is then in a condition to be sent into the depositing trough, which is filled with cyanide of silver solution, in which it is suspended by copper wires. The wires are attached to brass rods laid crossways on the copper-covered edging in the thickness of the wood of which the vat is made, and this being done, connection is formed with the galvanic battery; the result being, that the silver held in solution is released in minute particles, and attaches itself to the surface of the metal object. A silver coating of a greater or less thickness is secured, according to the length of time that the object is allowed to remain in the solution, the strength of which is kept up by plates of metallic silver being suspended in the vat. The loss of the metallic silver plates bears a due relation to that released from the cyanide solution and deposited on the articles coated, which are then removed from the depositing trough, boiled in pure water, and again dried in sawdust. The appearance presented on being removed from the vat is that of dead silver,—a dull metallic opaque white colour, and the brightness of silver is produced by the addition of a few drops of bisulphuret of carbon to the cyanide solution. The deadness in colour, which distinguishes the plated articles taken from the vat, is removed before burnishing, by the use of circular brushes, the bristles of which are represented by very fine-drawn brass wire, and during the operation of brushing, the goods are kept wet by the drippings of stale beer.

The next process is that of burnishing, in which women, aided with blunt-pointed steel tools with variously formed points to penetrate into every cavity, go over every part of the object. They next use burnishers of bloodstone, to impart the final brilliancy, the surfaces being lubricated with soap and water to prevent their being scratched. Spoons and forks, &c., subjected to frequent cleaning, receive their last touches by means of "rouge." In places which cannot be easily reached by buffs or brushes, the burnishing is done by hand.

The interior gilding of objects externally silvered, as cream jugs and sugar basins, is accomplished also by the electro-deposit process, but the cyanide solution, in this case, is permeated with gold. The vessel to be gilt is filled with a solution of gold, decomposition and deposition being effected by connecting the outside of the object with the positive pole, &c.; the end of the wire of the negative pole is dipped into the gilding fluid inside. The deposition of the gold commences immediately, and in a very brief space the inside of the object is gilt. All gold solutions are worked hot. Gilding externally is accomplished by the immersion of the article to be gilt in the solution, as described in the deposition of silver. Panel gilding, which gives additional beauty to works executed in precious or other metals, is also accomplished by the electro-deposit process. It is a simple operation, and is effected by "stopping out" with varnish the parts of the object which it is not desired to gild; and on immersion in the solution, the gold is readily deposited on those parts which are not protected.

Another department of electro-metallurgy is rapidly rising into an industry, if it may not already be said to be one, viz. the reproduction of articles originally elaborated by art workmen of the Mediæval and Renaissance period. Copies of works by the Ghibertis, Cellinis, Caradossos, &c., the originals of which are priceless and unattainable, can now be had at a minimum of cost, the result of the discovery and application of the principles of electro-metallurgy. Upwards of eighteen commemorative statues, varying in height from 6 feet 6 inches to 13 feet 6 inches, are the direct results of the copper depositing vats of Messrs. Elkington. Three of these statues are equestrian; the largest, that of Lord Eglinton, modelled by McDowell, is a grand and noble work.

Not only can the finest examples of the sculptor's art be reproduced, but the most fragile objects in nature can be equally preserved, such as flowers, insects, medals, or the most exquisite triumphs of the goldsmith's or jeweller's cunning.

Indeed, it may be said that electro-metallurgy, among all the metal-working processes, is the most generally facile and applicable for purposes of ornamental display, and it is by far the greatest of the many gifts, within the last forty years, bestowed by science on our national industries. Its discovery diminished human suffering, by substituting a harmless process of gilding for the baneful effects of the mercurial vapours, consequent on the process of gilding with gold amalgamated with quicksilver. It has furnished the artistic and industrial modeller with abundant employment, largely added to the demand for skilful "repairers" and "chasers," and originated a superior class of artizans, while it has vastly increased the number of ordinary workmen. Thus, in 1841, the employed under the Census definition of "goldsmiths, jewellers, and silversmiths" (platers were included also), numbered 10,755.

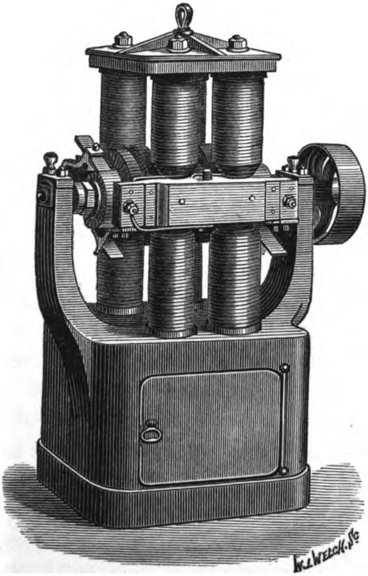
Plating by the electro process was introduced in the ten years which elapsed, so that in 1851 the number of workmen had increased to 13,250; in 1861, to 17,929; in 1871, to 21,530: males, 18,344; females, 3186. The increase in the numbers is clearly due (for the old mode of producing plated articles is at an end) to the development, application, and extension of the principles which, from copying a medal, by the reduction of metallic copper from a solution, led up to the reduction of the precious metals, as gold and silver, by the same process.

The electricity which is employed in the smaller establishments is usually supplied by means of galvanic batteries; but in the great works, where these would be attended with inconvenience, machines are employed for the production of the necessary electrical force.

Several different kinds of machines have been tried, that of "Gramme" being the most successful. This machine consists of electro-magnets, between the poles of which are rotated iron rings wound with endless coils of insulated copper wire. Commutators or collectors of the electricity are so arranged, that the current delivered is a continuous one, requiring very little engine power to produce, and not causing any heating of the apparatus. Fig. 1 shows a perspective view of one of the machines.

The galvanic battery of Daniell had been long presenting the phenomena of depositing copper, before any practical application of the principle was thought of, until Thomas Spencer, of Liverpool, first reproduced a medal as a practical result; scientifically trained minds picked up the solitary fact, and, reasoning there-from, proved conclusively, that what could be done with one, might and could be done with other metals more valuable. Then followed the scientific treatises of Smee, Shaw, Napier, and Watt on electro-metallurgy, which supplied the manufacturer of electroplated wares with practical information, to be made use of in the depositing room.

FIG. 1.



The workmen and women employed in electroplate manufacture occupy a high position among artizans. The business is a cleanly and healthy one. On examination it will be observed that one-sixth of the labour is performed by females

Casters of German silver get from 35*s.* to 40*s.*; fitters from 30*s.* to 50*s.*; stampers, 35*s.* to 40*s.*; polishers, 30*s.* to 35*s.*; chasers, 30*s.* to 50*s.*; assistant depositors, 30*s.*; engravers, 35*s.* to 50*s.*; embossers, 35*s.* to 45*s.* Females: burnishers, 15*s.*, 18*s.*, to 25*s.*

STEEL PENS.

By George Lindsey (Birmingham).

The modern implement for writing with a fluid is a very different thing to the pen of former times—the stylus and the calamus of the ancients, for example, which were used chiefly on the prepared bark of trees, palm leaves, or the papyrus of the Egyptians. Quill pens, still affected by a few old-fashioned penmen, only came into general use after the introduction of modern writing paper, and were made in immense quantities from goose feathers, now utilized for other purposes in connection with the industrial arts. The English name "pen" is from the Latin *penna*, a feather.

During the last century many experiments were made to improve the quill pen, the great defect of which was found to be its constant liability to injury from mere ordinary use, and the trouble of frequent mending; moreover, even the most skilful maker could not ensure uniformity of quality, and any variation in this respect affected the writer's work. These efforts were chiefly directed to fitting small metal, or even ruby points, to the nib of the quill pen, but the fineness and delicacy of the operation were so great, that but very little success attended the experiments. The quill, however, is not altogether discarded. A pen formed of the goose quill, in the shape of a steel-pen nib, is at the present time extensively made in Paris, and commonly used in England and the Colonies. The outer wing quills make the best pens of this kind, and some writers prefer them as a medium between the old style of quill pen and the steel pen. Ingenious machinery is used to manipulate the material to advantage: a machine with guides and a small circular saw, having very fine teeth, slits the quill, the concave halves of which are afterwards pressed, pointed, and slit under dies, in the same mode as steel pens. No waste is permitted, the plume or feather portion of the quill being utilized in the manufacture of children's shuttlecocks, or dyed and used by the makers of artificial flowers, &c.

The steel pen is of comparatively modern invention. At the beginning of this century pens began to be made wholly of metal; they consisted of a barrel of very thin steel, and the nibs were cut and slit so as to resemble the quill pen as closely as possible. The real inventor of the "knitting needle of civilization," as the steel pen has been not inaptly designated, has yet to be discovered. One of the earliest attempts to make a steel pen is attributed to William Gadbury, a mathematical instrument maker, who, for his own personal use, constructed a somewhat clumsy article from the mainspring of a watch, out of which the two separate halves or nibs were formed, and these being brought together were secured by a small ring or band of metal. Another amateur, Daniel Fellows, of Sedgley, Staffordshire, is said to have been one of the early metal pen makers, and a similar honour is likewise claimed for a Sheffield artizan, whose name, either from jealousy or forgetfulness, has not been recorded. The early history of steel pens is involved in obscurity, but reasoning from probabilities, I should say that Birmingham may fairly claim that the steel pen was first perfected by one of her manufacturers.

A great scientist and theologian, Dr. Joseph Priestley, was long resident in Birmingham, for whose personal use a split-ring maker named Harrison made a steel pen, with which the doctor wrote some of his famous polemical essays. It was rather rudely fashioned out of a piece of steel formed into a tube, the lower part being filed away into the shape of a pon, and the parts where the tube joined being left as the "split." Years afterwards one of the men associated with Harrison in his split-ring business—Mason by name—successfully embarked in the trade of pen making, and the same manufacturer (now Sir Josiah Mason), after realizing an immense fortune, which he has set apart to the founding of special educational and charitable institutions in the Midland metropolis, has just (January, 1876) retired from one of the largest pen factories in the world, which will henceforth be carried on under a limited liability company.

The name of Gillott deserves to occupy a foremost place in connection with steel pens, for by his own individual skill and enterprise was the first great impulse given to the trade. The early metallic pens were of very indifferent quality, and exceedingly dear. Pens which sold at from 6*s*. to 8*s*. per gross, forty years ago, are now procurable for about half the number of pence, while wages have improved, owing to the mechanical facilities of production. The chief fault of the first pens of metal was their hardness, which produced a disagreeable scratching of the paper. As early as 1820, Mr. Joseph Gillott, who dealt in the metal pens then made, hit upon an improvement, which, by removing this great defect, gave a stimulus to the manufacture, and caused it to be developed to an extent truly marvellous. This improvement consisted in making three slits instead of the single one formerly used, and by this means much greater softness and flexibility were acquired.

At the time when Mr. Gillott commenced operations, much of the beautiful machinery now in use had yet to be invented, and was subsequently invented, and for the most part perfected by himself. There were no such things as the "slip" pen, which now constitutes the staple of the trade—the thin piece of metal "raised" from the flat. Gillott adapted the press to the making of pens; he saw that this would enable him to dispense with most of the slow and laborious operations of pen making; that it would be possible to cut out the blanks, slit them, bend the metal, stamp the maker's name, and thus, by mechanical means, render production at once rapid and certain. The metal had to be prepared by annealing, pickling, and rolling for the action of the press; special dies had to be made for each size of pen, and for each operation of stamping to which the "blanks" had to be submitted; presses of improved construction—quick, light, easily worked, and yet strong enough to strike a sharp, firm blow—had to be made. And when these difficulties were overcome, there remained others not less formidable—such as hardening and tempering the metal after quitting the press, rendering the newly-made pens flexible, so as to write easily, cleaning and polishing them without injuring their fineness, and coating them with some kind of varnish, so as to render them more presentable to the eye.

This was the work which our great modern pen maker set himself to do; and with much ingenuity and unflagging perseverance he accomplished it. By degrees the press was adapted to the cutting, slitting, bending, and marking processes; machinery was devised for cleaning and polishing the pens; and experiments were made with the different qualities of steel, and the various ways of preparing it for use. At last Mr. Gillott attained the degree of excellence which has become inseparably associated with his name; and the trade ultimately reached the importance, perfection, and extent which characterize it at the present day.

Next to Mr. Gillott, perhaps, no one has done more to popularize the metallic pen than the well-known promoter of the "Perryian System of Education," Mr. James Perry. The characteristic of the "Perryian" pens was to give to the steel pen the elasticity which so closely approximates to the quill pen. Mr. Perry, with characteristic energy, almost forced the steel pen into use, when there were strong and deep-rooted prejudices against it. Commencing the manufacture himself in London, about 1824, Perry patented several varieties known as "Perryian Pens." It is stated on competent authority, that he used the best Sheffield "ribbon" steel, rolled out of wire, for which he paid 7*s.* per lb.; that he paid as much as 5*s.* per pen to the first person whom he employed to make his pens, and for years afterwards the price given to his workmen was 36*s.* per gross. Since the year 1828 Perry was supplied with pens of first-class quality by a Birmingham maker (Josiah Mason) who was content for many years to obscure his own name under the mark of "Perry and Co."

There are from twelve to twenty manufacturers of steel pens in Birmingham, which is now the head-quarters of the trade, some of them comparatively small firms; indeed the larger houses, whose products are in repute in nearly every market at home and abroad, may be counted on the fingers of one hand. These are Joseph Gillott and Sons; Perry and Co., Limited (embracing the late firms of Sir Josiah Mason, and A. Somerville and Co.); John Mitchell; William Mitchell; and M. Turner and Co. The varieties of pens made by these manufacturers may be numbered by thousands, being of every size, shape, and finish. In some instances a single manufacturer has two or three thousand distinctive "marks" made for different buyers, who require their own names or devices impressed on the pens.

The steel of which the pens are made is of Sheffield manufacture, a large proportion of it being supplied by Messrs. Jessop. It is cast steel of the best quality, made from Swedish iron, so as to secure in its granular structure peculiar density and compactness. These sheets are rolled in Birmingham, and, as a rule, on the same premises where they are to be worked up; they measure originally about 4 feet 6 inches long by 18 inches wide, and are afterwards clipped across into short lengths from 1¾ to 4½ inches wide.

These strips are first of all packed in cast metal boxes, and placed in a muffle or furnace, where the mass is heated to a white heat. This is called annealing, a process which fits the metal for further treatment on its way to the pen maker. After twelve hours of this roasting, the strips are cooled and then placed in revolving barrels, where, by the friction of metallic particles, the scales caused by the annealing, and the rough edges are removed. The strips are next immersed for some hours in a "pickle" composed of dilute sulphuric acid, which clears away the scale and imparts an even surface to the metal.

The steel is now ready for the rolling mill. The rollers consist of metal cylinders revolving upon each other. A man and boy attend at each pair of rolls, the first introducing the strip of steel between the opposing surfaces, and the boy pulling it out considerably attenuated. From the first pair of rolls it passes through several others, until, having been reduced in thickness to about the $\frac{1}{160}$th part of an inch, it assumes the requisite tenuity. Such is the degree of pressure employed, that the steel in passing through becomes hotter than it is sometimes convenient for unpractised hands to touch. At this stage the strip of steel is precisely the thickness of a pen, is quite flexible, and has increased in length from 18 inches to 4 feet 6 inches.

The first process of manufacture now begins, and before the series of operations have been gone through, some fifteen or sixteen distinct processes have to be completed. The strip is carried to the cutting-out room, where the pen first assumes form and shape. Here a number of women and girls are seated at benches, cutting out, by the aid of fly-presses, the future pen from the ribbon of steel before them. This is done with great rapidity, the average product of an expert hand being 200 gross, or 28,800 pens per day. Two pens are cut out of the width of the steel, the broad part to form the tube, if it is to be a barrel pen, and the points so cutting into each other, as to leave the least possible amount of waste.

The "blanks" are next taken to be pierced. The flat blanks are placed separately on a steel die, and, by a half circular action of a lever turning an upright screw, a fine tool is pressed upon the steel, and forms the delicate centre perforation and the side slits which give flexibility to the pen. All this time the metal is in its natural state of elasticity. It is necessary, however, that it should be rendered softer, and for this purpose the pens are again placed in the muffle to be further annealed.

Then comes the marking. On each side and down the middle of the room, a number of young women are seated at work, each of whom, while using her hands to properly adjust the pen and hold it in its place, moves by the action of the foot a lever actuated by treadle and wheel, and this marks the pen. When it leaves the hand of the operator, the back of the pen is stamped with the name of a retail dealer at home or abroad, a national emblem, an heraldic device, or the representation of some notability, foreign or domestic, according to the fashion of the day. The rapidity of this process is nearly equal to that of cutting out the blanks, each workwoman marking many thousands of pens in a day.

Up to this time the pen is flat. It has next to be "raised" into the half-cylindrical form in which we see the finished pen. The flat pen is placed in a groove, and a convex tool made to descend upon it, forcing it into the groove, by means of which it is bent into the required shape.

As a rule, the value of the pen depends very much upon the perfection of the slit. Those who can remember the difficulty experienced in getting a perfect slit in a quill pen, can understand how much less easy it is to prevent the gaping of a metallic substance. The first preparatory process, after the pens leave the raising room, is to return them once more to the muffle, into which they are introduced in small iron boxes with lids, and heated to a white heat. They are then drawn out and suddenly plunged into a large tank of oil, where, by the chemical action of the liquid on the steel, the pens attain a degree of brittleness that makes them crumble to pieces when pressed between the fingers. The oil adhering to the metal is subsequently removed by agitation in circular barrels made of tin. The brittleness has next to be corrected by a process of tempering. This is done by placing the pens in a cylindrical vessel, open at one end, and turned over a fire, somewhat like a domestic coffee roaster. The action of the heat gradually changes the colour of the pens, first from a dull grey to a pale straw colour, next to a brown or bronze, and then to blue—the latter betokening the highest degree of elasticity.

The pens are still rough, being covered more or less with small metallic particles. To remove this roughness they are placed in large tin cans, with sand, pounded crucible, or some similar substance. These cans are made to revolve by steam power, until, by rubbing against each other, the pens are cleared from roughness, and are brightened to the colour of polished steel.

Another set of processes now begins—those of grinding and slitting, also performed by young women. The nib is ground by picking up each pen with a pair of pliers, and applying it with a single touch to a rapidly-revolving wheel coated with emery, first lengthwise and then across the nib. This does for the pen the same service that the scraping of a quill with the penknife would do in the case of a quill pen, i. e. weakening certain parts to ensure uniform elasticity.

Next comes the slitting, which is done with the press. In these presses the descending screw has an exactly corresponding chisel cutter, which passes down with precise accuracy, by which movement the slit is made and the pen is completed.

There is yet something more to be done before the manufactured goods are ready for the warehouse—viz., the colouring the pens brown or blue. This is effected by placing them in a metal cylinder, which is revolved over a charcoal stove at a proper heat, and removing them the instant the desired tint is imparted. Brilliancy of surface is then given by immersing the pens in a solution of shell-lac dissolved in naphtha, and after drying, they are ready to go to the hands of the workwomen, whose duty it is to examine the work, throw out the pens which are defective, and count the remainder ready for the packers.

The presses, tools, and other appliances required in the pen trade are numerous and varied. In all well-regulated establishments, all these tools are made and repaired by special workmen on the premises.

On reaching the warehouse, the pens are packed in neat little boxes, each containing one gross. These boxes are usually made in another part of the manufactory, by a very simple but ingenious process. Successive layers of paper are pasted on to an oblong block of wood, and when the proper thickness is obtained, the outside ornamental layer having been added, the block is pressed on each of its sides with a sliding movement against a cutter of exactly the depth of the paper material, which is thus divided into box and lid, and the imprisoned mould set free. A glazed paper lining for the sides, made in a similar way, and exactly fitting the interior, is slipped into the box, forming a shoulder for the lid, and it is then finished.

Pen-sticks or pen-holders are made by steam power, actuating a number of machines constructed for the purpose. Most of the large manufacturers of steel pens make their own pen-holders; others, in a smaller way, buy them ready made. The trees or logs of cedar, or other suitable wood, having been sawn into boards, and again slit into thin square lengths, the rounding is managed by a machine in which a tube receives the end of each length, which, as it is drawn through to the other side, is subject to the paring of a couple of revolving blades. After this the material falls out at the other end perfectly cylindrical, although rather rough. The roughness is obviated by another similar machine, and a bundle of the long rods is then carried to a large mahogany slab, through a slit in which is seen about a third part of the disc of a circular saw. The rods are laid flat upon the table, and brought against a gauge which regulates the length; they are then pushed towards the saw and cut into sticks, a dozen or so at a time. These plain sticks have yet to receive the spiral pattern so much in vogue, to have the end which receives the holder reduced in size, and the other end rounded. These operations, when applied to the commoner descriptions of pen-holders, are not effected by cutting, but by pressing; and one machine suffices for the purpose. They are placed, about fifty at a time, in a receiver, and disappear one by one into a lower chamber, where the work is completed by dies, after which the sticks make their appearance in rapid succession through a tube, and fall into a box beneath. They are afterwards polished and varnished. The metal ends for the reception of the pen nibs are put on by hand.

Gold pens are extensively made in Birmingham, and as they resist the corrosive action of the ink, they are exceedingly durable; their durability is also greatly increased by the ingenious process of soldering on to the points of the nib minute particles of iridium, which, from their extreme hardness, resist wear for many years. Pens are also made in silver, zinc, amalgamated alloys, incorrodible platina, &c. Mr. W. E. Wiley, of the Albert Works, is the largest maker of gold pens in Birmingham. When the business of gold pen making was introduced as a local industry by Mr. Wiley thirty years ago, the retail price of such pens was a guinea each. The first of Wiley's gold pens were retailed at 5*s.* each, and now enormous quantities of gold pens are sold as low as a shilling each. This is owing to the adoption of improved machinery and appliances in the manufacture. At the time when gold pens were first produced by Messrs. Mordan, of London, and for many years afterwards, the usual method of slitting the pens was with the aid of diamond dust—a very costly process, since its uncertainty, by occasionally cutting wide gaps in the pens, caused no little waste of material. To remedy this, Wiley introduced a system of cutting the slit by means of emery on revolving copper cutters, which has been practised ever since. This so cheapened the production, as to enable a good quality gold pen to be sold retail at 5*s.*, for which a guinea was formerly demanded.

The same firm afterwards introduced a German silver, or white metal pen, known as the "Perryian Red Ink Pen," which still has an enormous sale. At these works Messrs. Wiley make pen and pencil cases in gold, silver, aluminium, gold, ivory, and vulcanite, in all patterns, shapes, and sizes, and varying in price, from half-a-crown a gross for common articles, up to the most ornate and costly that can be imagined. Some ten or dozen years ago the proprietor commenced the employment of female labour in his works, and with so much success that he has now upwards of three hundred girls trained to the work of making pencil-cases. The machinery has been specially adapted to this new order of things, and as the pencil-cases are all produced here on the interchangeable principle, the facilities of production are enormously increased. That these means to an end have solved a difficult problem, may be gleaned from the fact, that the weekly output of finished work at this establishment exceeds the possible production of all the pencil-case makers in the kingdom under the former system. Messrs. Wiley's works are now carried on by Messrs. Perry and Co., Limited, with Mr. Wiley as managing director.

PAPIER MÂCHÉ.

By George Lindsey (Birmingham).

Papier Mâché (French, signifying mashed or pulp paper), as a special branch of manufacturing industry, has been known in Europe for upwards of a century. Its use was probably first suggested by some of the beautiful productions of Scinde and other parts of India, where it is largely employed in the fabrication of boxes, trays, and such-like articles of domestic employment, as well as in China and Japan. In France its value was practically recognized at an early period, and the secret of its manufacture was subsequently imparted by a French workman named Lefevre to one Martin, a German varnish maker, who attained considerable fame as the first maker of papier mâché snuff-boxes, which, under the name of "Martin's," became popular all over Europe. The importation of papier mâché goods from France into Prussia was at one time so extensive that Frederick II. conceived and carried out, in 1765, the idea of establishing a manufactory in Berlin. The trade soon extended from the Prussian capital into several other German States, in all of which it was successfully practised, though it must be acknowledged that the articles produced in papier mâché at this period were of the simplest and rudest description.

Papier mâché was originally introduced into England as a material for making trays, with a view to enable our manufacturers to compete with the productions then largely imported from Japan. I believe that the real Japanese trays are made of wood, which possesses the very desirable quality of not being liable to warp; the best trays are covered with a peculiar kind of canvas, to which a coating of varnish is applied. The varnish employed is prepared from the simple juice of a certain tree indigenous to the country, and it is said that the heat of the sun is sufficient to dry it.

The Japanese method of manufacturing trays, however, like most of the native industries of the East, is shrouded in mystery, and as yet the "outer barbarians" resident in other parts of the world know but very little about it.

About the middle of the last century, Mr. Henry Clay, who was formerly an apprentice to the celebrated John Baskerville, of Birmingham, conceived the idea, that if sheets of paper were carefully pasted together upon a mould, either of metal or wood, an article might be produced which would successfully compete with Japanese work. Clay made experiments in this direction, which emboldened him in 1772 to take out a patent for "making in paper, high-varnished panels or roofs for coaches and all sorts of wheel carriages and sedan chairs, panels for rooms, doors, and cabins of ships, cabinets, bookcases, screens, chimneypieces, tables, tea-trays, waiters," &c. A contemporary record of the period says: "These articles are heightened with an elegance of decoration, which for design and execution are wholly unequalled." The inventor of the new material claimed that it could be sawn, planed or turned like wood, and that after being japanned, it could be brought up to the highest polish by friction with the human hand. Some of the articles manufactured by Mr. Clay are in use at the present time, and they fully bear out the character for durability which he claimed for his material. The result of Clay's discovery was a princely fortune for the inventor, and from his enterprise the papier mâché trade in England may be said to have originated.

There are several varieties of papier mâché known to the trade, each differing from the other in quality, materials, and mode of manufacture, according to the purposes for which the manufactured substance is required. These may be classified, as follows:

1. Sheets of paper pasted together over variously shaped cores or moulds of metal, according to Clay's invention.

2. Thick sheets or boards, produced by pressing ordinary paper pulp between dies.

3. Fibrous slab, which is made of the coarse varieties of fibre only, mixed with some earthy matter, and certain chemical agents introduced for the purpose of rendering the mass incombustible; a cementing size is added, and the whole well kneaded together with the aid of steam. The mass is passed repeatedly through iron rollers, which operation serves to squeeze it out to a perfectly uniform thickness, and the substance is then dried at a proper temperature.

4. *Carton Pierre.*—This, although often confounded

with papier mâché, is quite a different article. In its composition carton pierre more nearly resembles plaster than papier mâché, and, although stronger, is much heavier. It is made of pulp paper mixed with whiting and glue, pressed into plaster piece moulds, backed with paper, and, when sufficiently set, hardened by drying in a hot room.

5. *Ceramic Papier Mâché* (Martin's patent), a modern composition, which consists of paper pulp, resin, glue, drying oil, and sugar of lead, mixed in certain proportions, and kneaded together. This composition is extremely plastic, and may be worked, pressed, or moulded into any required form. The last-named material has been largely utilized in the production of cornices, capitals, plasters, and mouldings for architectural decoration, &c.

A patent non-conducting papier mâché for covering steam boilers, steam coppers, pipes, &c., has lately been introduced with success by Mr. M. Keenan, of London. This article is of great practical value to engineers, since it adheres to vessels of every shape and in every position without any external casings; and it not only prevents the radiation of heat and condensation of steam, but effects a large saving in fuel and labour.

On the expiration of Clay's patent, other manufacturers took up the trade, and, in addition to the production of finished articles of use and ornament, commenced the manufacture of papier mâché tray blanks, which they supplied to the japanners, who converted them by the ordinary process of ornamentation into finished goods. From one of these manufacturing firms sprang the justly celebrated house of Jennens and Betteridge. Sixty years ago, when Messrs. Jennens and Co. commenced business in Birmingham, they were sharp-sighted enough to discover how valuable this material would be for the production of furniture, desks, inkstands, writing folios, workboxes, and a variety of other fancy articles; and, carrying out this idea, aided by the best artistic talent in the trade, so far as regards ornamentation, this firm was enabled for many years to place in the market a constant succession of papier mâché wares of the most exquisite form and finish.

Birmingham was not alone in this department of manufacturing enterprise. The manufacture of papier mâché was introduced very early in the present century into Wolverhampton, first of all at the Old Hall, by the firm of Ryton and Walton, and was developed by them into a large and important branch of trade, especially in trays of different shapes, waiters, and bread-baskets.

The mode of manufacturing the "blanks" may be briefly described as follows:

In the manufacture of real (*i. e.*, pasted) papier mâché trays, the paper employed is of the very best and most expensive description, specially mixed and specially made for that trade alone. It is of a grey spongy texture, and is chiefly obtained from Farnworth Mills, Lancashire.

The moulds used were formerly of wood; they are now generally made of copper or tinned iron. The sheets of paper intended to make the trays are well soaked in a very strong paste made of superfine flour and best glue; four thicknesses of paper, thoroughly saturated with this paste, are put loosely together; they are then placed upon the mould, which has been previously well greased with Russian tallow, and worked into shape with the fingers of the operator. The extra paste is skilfully exuded at the edges by means of a small trowel, so as to leave no interstices by which air bubbles could form between the different layers. The mould with the thicknesses of paper upon it is then placed in a stove, heated to about 120°, to dry; and when the moisture is completely driven off, the mass is again subjected to the same process, which is repeated on each successive layer, until the required thickness is produced.

The next operation is to dip these tray blanks in a composition, the nature of which varies in different establishments, and this process has the effect of solidifying and hardening the material. The blanks are next dried in a hot stove; they are then taken to the making-up shop, and are planed and filed, until the surface is perfectly flat and the edges made perfectly true. The tray blank is now finally shaped, ready for the black stove, an operation with which everybody is doubtless familiar.

The exquisitely smooth surface of papier mâché is due to the fact, that the several coats of varnish are rubbed down with pumice stone, much in the same way as the outer surface of a coach-body is treated by the coachmaker. When the black stoving is completed, the trays are polished by hand, women labour being exclusively employed for the purpose; and at this stage the blank is ready to pass into the hands of the decorative artist, to receive the pattern or design which it is intended to bear.

In the ornamentation of papier mâché goods, both in Birmingham and Wolverhampton, the practice is to employ the highest available talent. I know several gentlemen of high position as artists, obtaining almost fabulous sums for their paintings, who owe their introduction to fame, and more than that, their rapidity of execution at the easel—as important to the japanner as the painter—to the systematic training and instruction which they obtained, while practically employed as workmen in the japan shops of Birmingham and its neighbour town. Bird, who rose to be a Royal Academician, was originally a workman at the Old Hall, Wolverhampton, and specimens of his very earliest attempts at painting are now in the possession of Mr. Frederick Walton, the present proprietor of the works, in which the manufacture of high-class papier mâché goods is still carried on.

For many years, domestic articles manufactured from papier mâché were admitted to vie in excellence and beauty of design with those produced in any branch of the ceramic art. But unfortunately the trade, especially as regards "fancy" articles, fell into the hands of retailers, who thought more of buying cheap and showy goods, than in selling a class of products, which would have been a credit to them as salesmen, and a source of satisfaction to those who purchased them. The greatest blow to the trade, however, was the introduction of a very cheap material, made from scrap-paper of the commonest kind and of every description. These "paper" articles were made, in fact, of *pulp*, under heavy pressure, and although they could be produced in large quantities, at very little cost, they were found to be totally unworthy of the name of papier mâché.

The decorative processes employed upon papier mâché ware have been the subject of numerous patented inventions, a large proportion of which have been abandoned or superseded by others of a more practical or more remunerative character. The more artistic of these new styles of ornamentation were applied almost exclusively to the best work. In 1825 Jennens and Betteridge took out a patent for a process of "inlaying" pearl shell on papier mâché, the invention of one of their workmen named Souter. This ornamentation was very effective when applied to trays, hand-screens, workboxes, card-racks, &c. The pearl ornaments were made from thin laminæ of shell, from one-hundreth to one-fortieth part of an inch in thickness; a patch of pearl was stuck with varnish to the article about to be ornamented, the design being pencilled on the pearl with a "stop-out" varnish, permitting the parts of the pearl not so protected to be eaten away by the application of nitric acid. The various patches of pearl being so treated, the surface of the article was blacked all over, and the superfluous varnish afterwards removed with pumice-stone and the ornaments displayed. The object was then polished with rotten-stone, and thus fitted to receive the additional gold or other enrichment. The beauty of this style of ornamentation was shown to great advantage in birds, sprigs, and other designs scattered over the surface of the article, which was treated entirely without colour, and was at once chaste, neat, and durable.

In 1832 another style of ornamentation was introduced by the same firm. This was originated by Edwin Haseler, who, having just completed his apprenticeship with Jennens and Betteridge, then began his career as a workman with an improved style of flower painting. Up to that period the flowers introduced upon papier mâché were not imitations of nature, but a sort of Chinese impasto ornament. Natural flowers were now painted upon the centre of the article, to which was given a border of light ornamental goldwork, at once chaste and beautiful. This was regarded by the trade as a bold step, but it seemed to hit the public taste, and the patterns put into the market continued to sell freely for nearly thirty years.

The desire to produce something new, induced Mr. Farmer, of Birmingham, in 1844, to associate electro-deposit medallions with papier mâché in salvers, card-baskets, portfolios, &c.; and a year or two later a new style of pearl-shell decoration behind glass was introduced by Mr. Joseph Gibson. In 1845 a new and pleasing style of ornamentation of papier mâché articles was adopted at the Old Hall Works previously mentioned, and had a marvellous run for a number of years. This was the selection of interior and exterior views of the old baronial halls of England, and the various cathedrals. These subjects were produced principally in bronze, finished in gold and colours, the figures being delicately painted in oil. In this series, by the imitation of stained glass windows of cathedrals, &c., the effects produced were remarkably good. These effects were obtained by the judicious use of transparent colours upon pure gold and silver. Landscapes, too, were admirably rendered in the same material, the skies in particular being singularly effective and natural.

Each and all these new methods of decoration involved more or less the employment of hand labour. Other inventors, however, were soon ready with methods for the multiplication, almost indefinitely, of various styles of ornamentation by mechanical means. In 1852 Mr. Haseler, of Wolverhampton, patented what was called "the negative process, for producing ornamentation in burnished gold upon japanned or other bright surfaces." By this means a full finish was imparted to the ornament. The pattern was produced from an impression taken off on previously prepared thin paper, from a lithographic stone or copperplate—properly designated a *negative* design—*i. e.*, the surroundings of the ornaments (the parts that are not required to be in gold) only being transferred. After the negative was transferred to the surface of the object, it was covered all over with leaf gold, the size being composed chiefly of isinglass and water, and when dry the whole surface was rubbed over with spirits of turpentine, which dissolved the "stop" underneath the gold, leaving the parts which the transfer had not touched, sharp, clear, and perfectly finished. This process was worked satisfactorily for some years by one of the leading houses in Wolverhampton. Mr. C. Breese's invention, patented about the same time, was so far dissimilar, as to be absolutely the reverse of the Haseler patent. Breese first gilded the surface to be ornamented, and upon that surface transferred the ornament which he wished to appear, taking the superfluous gold off first with water, then removing the transfer "stop" with spirits of turpentine. Haseler's invention was doubtless the more simple, because in his process there was only one clearing off—the one application of turpentine taking away both the gold and the "stop;" with the Breese process, water was requisite to take away the gold, and turpentine to clear away the "stop." Breese's patent was applied almost exclusively to glass and porcelain surfaces.

Shortly after the introduction of the cheaper kind of material already described as *pulp*, a morbid taste arose in the Birmingham japan trade for placing great blotches of pearl upon articles made of pulp, and finishing them in the gaudiest of colours. Nothing in worse taste could possibly be conceived. Certain manufacturers finding it more profitable, for the moment, turned their attention to and encouraged the production of their meretricious decoration, to the neglect of better and more carefully studied work; and pearl landscapes, pearl ruins, and pearl flowers and fruit seemed destined to supersede the admirable artistic productions of such men as Haseler, McCallum, Stanier, and others of a like calibre. Under these circumstances, some twenty years ago, trained workmen had the painful alternative either to pander to a depraved and vulgar taste or leave the trade. The former course was pursued by some of the artisans, while others honourably and profitably turned their attention to other more genial occupations.

But while this tendency to over-elaboration of ornament, fostered principally by the production of goods for the United States and other foreign markets, was undermining the trade, there were other mischievous influences at work in the same direction. The public had been taught to believe that in purchasing papier mâché or pulp wares—for the two totally distinct fabrics are still ignorantly supposed to be one and the same—the quantity of material was the test of value, and they naturally asked for more pearl and more gold. To enable the manufacturers to comply with this demand, the extra cost of material had to be met by a reduction in the price of the workman's labour, and further disregard for the quality of the work, so that eventually children came to be employed very largely as ornamenters.

For these reasons the trade in real papier mâché was long in a declining state. It is now in a more hopeful condition. Within the last two years a fresh demand for the best description of papier mâché has sprung up, and still continues. At length purchasers refuse to invest their money in elaborate examples produced in a depraved taste and vicious style, regardless of the material of which they are made and the purpose for which they are intended. This wholesome change is much appreciated by the better class of manufacturers, and is fostered and encouraged by them with most beneficial results. The firm of Jennens and Betteridge no longer exists, but another leading Birmingham house—that of McCallum and Hodson—successfully imitates those worthy pioneers of high art in the better style and ornamentation of this class of ware.

The old showy, gaudy, unnatural style of flower decoration will now only sell, at most unremunerative prices, among the lower classes of society in Europe, and among the uncivilized masses in other countries. The styles now in vogue are chaste and decided in character, such as the Grecian, or Etruscan, or Persian; or if pearl inlaid, very neat narrow pearl lines and ornaments. A good demand for best finished goods is now springing up, and the trade is in a more healthy and thriving condition than it has been for many years. Artistic, really clever men, who can produce novelties and well-executed designs, are at a premium, and can obtain very high wages.

Oddly enough, papier mâché trays of the forms and shapes that were popular half a century ago, are in renewed demand at the present day, and stranger still, the ornamentation on these trays has once more reverted to the old Japanese style of enrichment, in which Booth, the artist (the father of John Wilkes Booth), who worked as a japanner at the Old Hall, was never excelled.

The number of workpeople employed in this trade in Wolverhampton is about 600, chiefly in the decorative, polishing, and finishing branches. A few chairs, cabinets, and pianos are made in London; but the great seat of the trade is Birmingham. The papier mâché manufacturers in the latter place are not more than twelve, some of them very small employers of labour; the number of hands is probably 750, comprising men, women, and boys, the latter as apprentices in learning the art of painting or gold ornamentation, women in the stoving and polishing, and men in cabinet making and decorating, and lining with silk velvet, &c.

Papier mâché ornamentation, as applied to architectural designs and enrichments, received a considerable impetus from the patented inventions of Mr. Bielefeld, now carried on by the London Papier Mâché Company, Limited, at their steam mills, Staines, Middlesex. Builders and architectural decorators have not been slow to avail themselves of the adaptation of papier mâché to the purposes of decoration, since it is found to add so much to the finish and market value of houses and public buildings. The variety of purposes to which this class of papier mâché can be advantageously applied is almost innumerable. For example, it is expressly made for bosses, brackets, canopies, cantilevers, capitals of columns and pilasters, caryatides, ceilings, ceiling flowers, chimera, chimney-pieces, consoles, corbels, cornices, enrichments, festoons, finials, flowers, frames, friezes, furniture, leaves (from nature), mouldings, organ cases, panels (Gothic), pateræ, pendants, picture frames, pinnacles, royal arms (various), rosettes, screens, scrolls, sculpture (copied), tables, termini, tracery, trusses, ventilators, window cornices, &c. The leading articles in this category are the centre flowers for ceilings; these are, in common with corresponding fittings, from designs by high-class artists, architects, and sculptors, and all are characterized by sharpness of outline, deep undercuttings, and a consequent richness of effect entirely unknown in plaster, and not unfrequently equal to the highest order of carving and sculpture.

No other material is so eminently adapted for these purposes as papier mâché. It is found to combine the qualities of slight pliability with lightness and extreme hardness; it is tough, durable, and economical, and without tendency to chip, warp, shrink, or fracture; and it may be steamed to almost any shape or curve. The forms into which it is manufactured possess all the characteristics of the finest wood carving, with remarkable force and boldness of relief, while, being devoid of the grain of the wood, it is not liable to split or sustain injury.

The processes of manufacture, as carried on at the Company's mills, are very simple. The material used is the best brown paper (old) for the strong or back stuff, and the best white for the facing material, which is put on at a second pressing. The paper and ingredients are placed in a mixer, and thoroughly well churned up, and afterwards rolled out in sheets, which are placed in metal dies and pressed, either by screw or hydraulic power; the ornaments are then dried in a hot room, and afterwards trimmed. The larger ornaments, centre flowers, &c., are of course pressed in parts and afterwards joined up by "mounters." This pressing involves the use of some 50 tons of dies, chiefly of brass and type metal, prepared at a cost of 30,000*l.*, and a great many tons of large plaster moulds. The mixing, rolling, wood-cutting, and other machinery are driven by steam power; the drawing and modelling, requiring a high class of skilled labour, are done on the premises; and there is a separate foundry shop for the preparation of the dies, which require careful chasing up before being used. The subsequent gilding, colouring, bronzing, &c., of the work is done in a separate department. It is marvellous how readily papier mâché can, without "stopping" or preparation, be gilded, silvered, painted, or bronzed. The art of bronzing upon this substance has been brought to very great perfection, and is applied here with such success to bas-reliefs, brackets, figures, &c., that the difference between the metal and the bronze papier mâché is very difficult to detect, and almost impossible to define. Majolica is also imitated with even greater success, the special treatment bringing up the gradations in shade and colour so faithfully as to defy detection. Ornaments prepared in this way may be washed and cleaned without detriment to the fabric.

AMMUNITION: PERCUSSION CAPS AND CARTRIDGES.

By George Lindsey (Birmingham).

The term "ammunition" applies exclusively to the projectiles and explosive substances employed in warfare, or in the priming and loading of small arms used for sporting purposes, and necessarily includes shot, shell, gunpowder, cartridges, fuses, wads, grenades, &c.; though sometimes rifles, swords, bayonets, and other small arms are erroneously classed under this designation. The ammunition for the British Army and Navy is chiefly prepared at the Royal Laboratory at Woolwich. The cannon balls may be cast at some of the large iron foundries in the North of England; the military rifles may be the production of Birmingham or the Government factory at Enfield; the gunpowder may come from Waltham Abbey, but the bulk of the making-up of what is strictly speaking ammunition, devolves upon the staff of the Royal Laboratory. Here bags of serge are cut out and made, and in enormous numbers fitted to form the cartridges for large ordnance; bags or tubes of paper are made and filled to constitute cartridges for small arms; and the tubes and combustibles for war-rockets and fuses are also manufactured. But Birmingham must be regarded as the great seat of this special industry, as it is of the gun trade, for which her manufacturers have attained a world-wide celebrity. In the capital of the Midlands the cartridges for every class and description of small arms—rifles, muskets, carbines, and pistols—are made in quantities measured by hundreds of millions annually; and much of this enormous product is contracted for on behalf of the different foreign military Governments, since it is on reliable supplies of ammunition that the main offensive operations of an army depend.

It has been calculated by the Woolwich authorities, that a British army of 60,000 men, comprising a fair average of infantry, cavalry, artillery, and engineers, ought to be provided with no less than 18,000,000 ball-cartridges for small arms, for six months' operation. These would require a thousand ammunition waggons, and 3600 horses to convey them all at one time. It is therefore deemed better that, under such circumstances, there should be established entrepôts for supplying the troops from time to time. The waggons constructed for this kind of service will carry 20,000 rounds of small-arm ammunition each; the cartridges are packed in boxes, and the waggons are drawn by four horses each. Several waggons are organized into an "equipment," under the charge of a detachment of artillery; and there are several such equipments for an army of the magnitude referred to—one for each division of infantry, a small portion for cavalry, and the rest in reserve. It has been laid down by the best military authorities, that an army of 60,000 men ought to have with them no fewer than 2,680,000 cartridges, besides those held in reserve; and the conveyance of such a quantity, with a few forges and stores, would require 150 ammunition waggons, 830 men, and 704 horses. The equipment would of course return to the entrepôt for a new supply when needed. In the Peninsular War and at Waterloo the English used two-horse carts, carrying about 10,000 rounds of small arm ammunition each; but a much superior kind of waggon has since been introduced. During peace, the Woolwich Laboratory serves out little less than a million pounds of gunpowder annually, in ammunition for the Army and Navy, for purposes of exercising, saluting, &c. As may be supposed, the quantity in war is indeterminable. It is important to bear in mind that when the projectiles for artillery, their cartridges, primers, &c., are packed in the same box, the same is termed "fixed" ammunition; the term "unfixed" ammunition being given to the unloaded shells, case shot, and grape shot.

An explosive force of fulminate was long felt to be necessary to supersede the old-fashioned method of flint ignition in discharging fire-arms. So far back as seventy-five years ago, Howard's fulminating mercury was described and experimented on before the members of the Royal Society; in Mr. Howard's experiments, however, he failed to compass the idea of applying the compound practically to the discharge of fire-arms, since he modestly acknowledged that "it was pretty plain that no gun could confine a quantity of the mercurial powder sufficient to project a bullet with a greater force than an ordinary charge of gunpowder." A few years later Mr. Alexander John Forsyth, a minister in Aberdeenshire, patented the percussion lock—an invention which was unsuccessfully disputed on the ground of prior use; for notwithstanding that the private use of the percussion lock by others was clearly proved, Forsyth's patent was upheld.

Copper caps were not used with the earliest percussion arms. Before caps were introduced, a magazine gun was brought out by Mr. Westley Richards, a Birmingham gun maker, which attracted some attention. In this gun there was a little magazine of fulminate arranged in front of the hammer; as the hammer of the gun was raised, it brought the magazine over a small cup occupying the place where the nipple is put under the hammer of the percussion gun, and a direct blow from the hammer on the top of the fulminate in the cup sufficed to ignite the charge. This magazine gun had a short run, but was never very popular with sportsmen, for reasons that will be apparent to anyone accustomed to the use of fire-arms.

Meanwhile the copper percussion cap had been invented, and was found to be a considerable improvement upon the detonating plan of ignition. The percussion lock was now a very different thing to the old flint-lock, being divested of three awkward features in the latter, namely, the hammer, hammer-spring, and pan; nothing appeared upon the lock-plate, but the cock or striking-hammer, which gives the striking-blow upon the cap. This cock was concave, with a small metallic ring or border, called a shield or fence, for the purpose of enclosing the cap, as it were, and preventing its splinters doing personal injury to the sportsmen, as also forming a protection against the line of flame which may issue from the touch-hole in the cap-nipple. This was screwed into the breech of the gun and perforated with a small hole.

The manufacture of percussion caps, as originally carried on, is an extremely simple process. A sheet of thin copper is stamped into pieces of appropriate shape to form small cylinders, and these are bent into the form of caps by a stamping apparatus closing round a mandril, the whole being done in one machine by two operations.

The caps are next placed in a tray, mouths upward, and the inside of each is touched with a strong adhesive varnish. On this is dusted the detonating powder, all the particles which fail to adhere being blown, dusted, or shaken out. "A stamper" is once more forced into the cap to fix and compress the powder, and the operation is complete. Large numbers are filled and stamped together, so that many thousands of caps per hour may be turned out by one machine.

For muskets, the caps are charged with equal parts of fulminating mercury and chlorate of potash; for cannon, with a mixture composed of two parts of chlorate of potash, two parts of native sulphuret of antimony, and one of powdered glass, the last ingredient taking no part in the chemical action and being added to increase the friction.

Westley Richards was the first gun manufacturer to adopt the percussion cap and to fully recognize its advantages, and his example was shortly followed by most of the other gun makers. There was, however, in high quarters considerable prejudice against its adoption. The copper cap was first of all offered to the Government for use with the naval guns of the period. It was objected to, because, amongst other reasons, it was thought probable that the exploded particles of copper would be thrown carelessly about on ship-board, and that the sailors might hurt their naked feet by accidentally stepping on them. On this humanitarian ground the percussion cap was rejected by the Government. To obviate this objectionable feature, Richards' patent "Patch" was invented. This consisted of a flat piece of metal enclosing the fulminate, the whole covered with paper, so that a spent "patch" was converted into nothing more mischievous than a flat piece of paper.

The "patch," it must be acknowledged, never was very popular, and it could not in any sense be said to have thrust the copper cap out of the market. The copper cap originally was very badly made: neither the metal nor the workmanship were equal to the purpose or the occasion, and owing to the pieces of copper flying about in dangerous proximity to the eyes of the sportsman, it was obvious that some contrivance must be introduced to do away with this danger, or that copper caps must be made better and stronger.

In 1837 the inventor of the "patch" brought out a "Patent Primer," in which the fulminate was enclosed in a small metal tube, made to slide into a wide-topped nipple and having flanges, so that there would be no fragments flying about on the nipple being struck by the hammer. So safe was this invention considered by the old school of sportsmen, that they clung to it with more or less pertinacity until within the last year or two. On the whole the "Primer" had a fair amount of success for some years, but the percussion cap trade had in the meantime assumed a foremost position; the quality of the metal and method of manufacture had materially advanced, and machinery of enormous power was employed in their production to supply the constant demand for these articles in every quarter of the globe.

The process of punching percussion caps out of sheet metal by means of the press is much like that employed in the cutting out of steel-pen blanks,* and this part of the manufacture has no element of danger about it.

The filling, priming, and drying departments are, however, highly dangerous, requiring the utmost precautions and rigid rules to carry on the work without accident. The Holdford Mills of the National Arms and Ammunition Company, Limited, near Birmingham, afford a good example of what is necessary to be done in this respect.

"Each morning every one of the workpeople, before commencing the duties of the day, enters the 'shifting room,' where he or she undergoes a rigid inspection. They divest themselves of their shoes, substituting woollen slippers, and dress themselves in clothing of a non-combustible material; and they are compelled to leave behind them every bit of personal property in iron or steel they may happen to have about them—all matches, fusees, tobacco pipes, and other articles enumerated in special and elaborate rules posted on the walls of the building."

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* *Vide* article on "Steel Pens," page 151.

An ordinary visitor has to obey the same regulations, except as regards the change of clothing, and brown leather shoes, innocent of tips, nails, or sprigs must be worn. The dangerous processes are carried on in a series of wooden huts, erected in a large field, each being placed many yards from the other, in which the operations of priming caps, filling cartridges, and charging fog signals are carried on. It is important to observe that after leaving the "shifting room," no one is allowed to step off the wooden platforms which lead to each shed; indeed, the precautions observed at the above-named works are of the most elaborate and exacting description. They are absolutely necessary, and it is for the protection of the workpeople themselves that the managers insist on their being so strictly carried out.

In the priming of percussion caps two modes are followed: in one, fulminating powder is used; in the other, composition. The fulminate is wetted until it resembles paste; and then in a very ingenious manner, by rubbing it across a perforated brass plate, small cakes, each sufficient for one cap, are formed and placed into the copper cases. This paste is afterwards covered with a small disc of tinfoil, and gently pressed home; the caps finally being dried in steam-heated ovens. The composition is used in its dry state, a sufficient quantity for each cap being measured out by an extremely clever process, and many caps charged at one time. The powder is finally fixed in the cap by a small quantity of varnish of a peculiar description being dropped into each.

With the invention of breech-loading fire-arms, a new system was introduced, which, dispensing entirely with the nipple and percussion cap, supplied self-contained ammunition, i. e. a cartridge carrying its own ignition. Cartridges had long been in use for small saloon pistols, and their ignition was accomplished in this way: The whole base of the cartridge was primed with fulminate; there was no cap, and the striking any part of the base by means of lock hammer, ignited the charge. The danger of this was obvious, since the whole base of the cartridge entirely charged with fulminate was exposed more or less to friction, and the liability to accidental explosion correspondingly increased.

A paper cartridge to carry its own priming was next brought out, and subsequently cartridges were made carrying their own ignition, suited for both sporting and military purposes: one of these contained a cap and anvil placed at the base. Next an element of safety was introduced in this kind of cartridge, by placing the charge in the centre of a metal disc, so as to receive an ordinary percussion cap and anvil. The "Boxer," "Eley," "Snider," "Dawes," and other cartridges followed, all involving the use of caps and anvils.

A cartridge having the fulminate in the base is struck out of one piece of metal; nearly all the others are in compound cases—a portion of paper, paper pulp, &c., just to accommodate the peculiar kind of weapon or purpose for which they are required. One kind was made with a head of metal, the tubular portion being made of paper; others again wholly of metal, with the addition of a cup at the base to contain a cap and anvil, the bottom of the cup supporting the anvil.

Finally a patent cartridge—known as Jones's patent—was brought out, possessing far greater advantages. A peculiar feature of this invention is that the whole of the case, cap chamber, and anvil are all struck simultaneously out of one disc of metal, the raised cap chamber acting as the anvil. The superiority of this arrangement over others in vogue has been so universally acknowledged, that at the present moment nearly all the military Governments in the world, except our own, have adopted it. The Americans early appreciated its advantage. It has already been used by the British War Department for the Gatling gun, and I am informed that, as the result of recent experiments, it is probable that Her Majesty's Government will shortly adopt the Jones cartridge for all departments of the service. The objection to the Boxer compound cartridge is that, being made mostly with an iron disc, in practice it is found, that in the mere attempt to utilize the waste—that is, separating the iron from the copper—the process is actually more costly than the value of the metal when recovered. The Jones cartridge with the Westley Richards improvements is specially adapted for military purposes. The first cost is certainly rather more than that of the ordinary kinds of cartridge, but there is an advantage in an economical point of view, as the Jones cartridge cases may be refilled and used forty or fifty times, which is a special merit where it is the practice, such as at drills, to save the cases and have them re-capped and re-loaded. The principle of this cartridge is applicable both for carbine, musket, and every description of rifle cartridges.

It is known that a great many of the cartridges used for sporting purposes are made of paper; but the tendency of modern practice is in the direction of metal cartridges, or cartridges with metal back ends. These are convenient for use abroad, or in localities where supplies of ordinary cartridges cannot be obtained, since the metal cases may be readily refilled and re-capped for use as required; and this operation may be repeated many times with the same cases. The Birmingham houses, in their contracts with foreign Governments, always stipulate that the cartridges contracted for shall be capable of being re-loaded at least ten times before breaking or splitting.

The first stage in metallic cartridge making is the casting and rolling of the metal. This latter operation does not differ in any degree from ordinary metal rolling. The brass comes ready to hand in long strips, say two inches wide, and of a suitable thickness. These strips are first coiled and then allowed to pass between the rollers of a machine, which carry them on to a small anvil, where, with great rapidity, circular pieces of the metal of about the size of a half-crown are stamped out, and by the same blow driven into a die, where they receive the shape of a small cup, about half an inch deep. These cups are next carried to an adjoining shop, and there annealed, when they are passed to another machine which forces them into a smaller die, and thus increases the depth, while it decreases the diameter of the cup. In making military cartridges, this process, technically termed "drawing," goes on six or eight times in succession, and the annealing is repeated every time. Thus by several processes of annealing and stamping on various machines, the cartridge case passes on until it has been drawn out to a depth of about three inches and to a diameter of about half an inch. By an ingeniously contrived machine, the case is instantly and clearly cut to the required length. Next it is passed to a machine which flattens the lower end and drills in it a hole to receive the detonator; and a head is formed at the base of the case with a cap chamber and outer rim or flange, by which the empty case is extracted from the rifle. The case then goes to other machines, which pare down the flange, so that it will exactly fit the bore of the rifle, and compress the upper end or mouth of the case, to enable it to clip the bullet tightly when it is inserted. Finally, the case is thoroughly washed and cleansed; and, having been carefully examined as to its accuracy of size, &c., by being passed through holes in iron plates of exactly the same gauge as the rifles for which it is intended, it is completed.

The filling of cartridges requires great care. The bullets are first wrapped in thin paper, next greased, and finally inserted in the end of the cartridge case, into which the necessary charge of gunpowder has been introduced. In metal-cased cartridges the bullets have to be inserted by machinery, the bullet being forced home on the powder by a firm pressure of the machine, which works with the utmost nicety and precision. Paper cartridge-cases are made in a very expeditious manner. Long strips of a peculiar kind of brown paper are passed through a machine, the rolls of which cover the paper with glue. In another machine the paper is rolled on steel spindles, and the cases thus formed, when dry, are very strong and hard. They are next cut, shaped, and fitted with brass heads, thick and strong paper wads being forced in at the lower end of the cases, in which are perforations for the reception of the detonator.

A wonderful impetus has been imparted to this branch of manufacturing industry during the last few years, owing to all the great military powers turning their attention simultaneously to the improvement of their chief weapons of warfare in small arms; and the resources of the trade in London and Birmingham are now such as to enable contracts for millions upon millions of cartridges being turned out of hand in an incredibly short space of time. The demand for military cartridges is, however, fitful and uncertain, and while sometimes business languishes for lack of customers, a sudden order will put all the men and machinery of the great cartridge-makers into active operation, which hardly ceases day or night until the whole of the work has been delivered. The demand for ordinary kinds of ammunition used in sporting small arms and revolvers is more regular, though the aggregate production is barely a tithe of that required for military purposes.

ANCHORS AND CHAIN CABLES.

By George Lindsey (Birmingham).

The anchor, as an implement for retaining a ship in a particular spot, by temporarily chaining it to the bed of a sea or river, was in pretty general use by mariners long before Britannia was allowed, by common consent, to "rule the waves," as the acknowledged "Mistress of the Seas." Pliny and other writers give the Tuscans the merit of the invention, though other people have an undoubted claim to share the credit of developing and perfecting the anchor as we now see it. Originally anchors were made of stone, or of logs of wood, covered with lead sufficient to make them sink in water; and these were succeeded by a bent rod with a single fluke or arm for penetrating the ground.

The first iron anchors are supposed to have been used by the Greeks. As originally introduced, these anchors had only one fluke, but a second was afterwards added, though in that altered form, being without "stock," an anchor was ill-suited for ensuring a firm grip into the ground when lowered. The Greek vessels had several anchors, one of which, called the "Sacred Anchor," was never let go until the ship was in dire distress. Some such custom was long known in the British Navy, but it has of late fallen into desuetude. Of whatever form or material the ancient anchors were made, they were lowered from the ships' sides by means of hempen ropes, chain cables being a comparatively modern invention.

The general shape of anchors is well known, consisting of two arms terminating in broad expansions termed "flukes," and attached to a long shank, to which is fixed a stock of wood or iron at right angles to the arms, to ensure the perpendicularity of the flukes when the anchor is on the bottom, in order that they may take firm hold of the ground. Small anchors termed grapnels, and having four or more arms, are used for boats, and at times for small vessels. The mushroom anchor—so called from its shape—is principally employed in the East Indies by the native vessels termed "grabs."

The number and weights of anchors in British ships-of-war are nearly as follow:—Men-of-war have four anchors—the "best bower," the "small bower," the "sheet," and the "spare." For particular and special services, there are also the "stream" and the "kedge." Smaller vessels have fewer and smaller anchors; and the "stream" anchor of a large ship may conveniently serve as the "bower" for a smaller. There was at one time a rough-and-ready way of estimating the relative weight of anchors required for the British Navy. For example, the chief anchor for a man-of-war should weigh as many hundredweight as the ship carried guns: viz., a 90-cwt. anchor for a 90-gun ship. In the mercantile marine it was reckoned that the chief anchor should weigh one-twentieth part as many hundredweight as the ship measured in tonnage: thus, a 300-ton ship would have an anchor of 15 cwt. The weight of an anchor 10 feet long used to be laid down at 11·4 cwt., and that of an anchor 14 feet long at 30 cwt. These numbers and ratios are, however, no longer trustworthy, since new forms of anchors, the use of chain cables, the introduction and development of steam navigation, and the building of ships of great magnitude, have rendered most of the old formulas inapplicable to the present day.

The largest anchor in the world is that which was specially forged for the *Great Eastern* steam-ship, some years ago, at the works of Messrs. Parkes, Tipton, Staffordshire. It is in form somewhat different from ordinary anchors, the palms or blades being divided or split, so that it may more readily pierce the sea-bottom. Its dimensions are: length of shank, 29 feet 6 inches; of wood stock, 19 feet 6 inches; trend of arms, 7 feet 4 inches. The weight of this anchor is 8 tons, exclusive of the stock.

The anchor, having to act in all grounds, in all positions and in all weathers, and further, to combat the elements, its first condition must be the simplicity of its form and construction. Independently of these two main conditions, it is imperative that an anchor, in order to respond efficiently and with certainty to the multifarious requirements of its service, should possess certain qualifications, not merely such as are to be deducted from theoretical explanations more or less scientific, and by means of models, but as the result of numerous practical experiments with anchors of all dimensions ashore and afloat, and confirmed by constant use during a series of years and in various anchorages. These qualifications are thus enumerated: (1) The principal parts of the anchor must exert simultaneously their holding power; (2) no portion must project when at anchor, and endanger the ship's hull; (3) its holding power must be instantaneous in all kinds of ground; (4) when let go, it must always fall in a position to grasp the ground; (5) its holding power must be very great and certain, in hard, muddy, and sandy bottoms, or in shingle; (6) it must not foul, nor become fouled, nor entangle the chains in an anchorage; (7) it must be comparatively light, but very strong, compact, and occupying little space; (8) its stowage must be easy; (9) it must be "fished" easily, even when the ship proceeds; (10) it must "cat" flat, and not stand in the way of outward riggings; (11) it must trip easy in all grounds; (12) its working must be certain, and to be relied upon; (13) it must clear the keel and prow when heaved up; (14) it must be, when necessary, easily taken to pieces; (15) it must be entirely free from weldings; (16) its cost must be proportionately moderate; and (17) it must be so strong as not to break when let go on hard or rocky bottoms.

After repeated severe tests, the British Admiralty have decided that these requirements are more or less supplied in Martin's Self-canting Anchor, which introduces a new principle in the mode of construction. Martin's patent anchor has two arms on a parallel line, acting on a swivel and at a proper angle, both of which take hold of the ground simultaneously, instead of one only, as in the ordinary and other description of anchors, thereby giving the anchor double the holding power, while it offers less resistance when in the act of being raised. This anchor has no stock, but it has what are called "steadying arms," which have holding power almost equal to that of the two arms, especially in shingle or muddy bottoms: these parts, combining and acting together, make the anchor at once a powerful and efficient ground tackle. A great saving, from the difference of weight, contrasted with that of the ordinary anchor, for the same tonnage of vessel, is due to the peculiar form and construction of the Martin anchor; for although the manufacturing price per hundredweight is above that of the ordinary anchor, in consequence of the difference in weight and the saving effected in the year for working it, its real cost is actually less. The Martin anchor only occupies about half the space of the old-fashioned anchor; and applied to iron-clad ships, it is entirely out of the line of fire when stowed away. The British Government have adopted this patent self-canting anchor for the Royal Navy, and already about forty of Her Majesty's ships have been fitted with it, while it is also in use in the navies of France, Canada, and the United States.

Tyzack's patent anchor is another improved form of anchor, of simple construction, great strength, and capable of quick biting and powerful holding. Unusual strength is attained by the anchor having no welds; and, being fitted with only one arm, the various parts of the anchor are thus increased in strength to make up the regulation weight; and this increased strength is very considerable, when it is remembered that each arm of an ordinary anchor is 25 per cent. of its total (ex stock) weight. Quick-biting is effected by the elevation given to the crown by the projecting T piece on the arm, which, assisted by the weight of the palm or fluke, throws the point of the palm at once into a position to take the ground. In this anchor a modification of the Rogers palm has been adopted, but it has been increased in length to obtain still more holding surface, and has a solid rib on both sides, thereby adding further to its strength. The shape of the anchor, and the having the reversible arm lying secured between the open shank, renders it, in nautical language, "snug," and very easily handled. It can thus hang at a ship's bows without coming in contact with the plates or planks, as the sharp point of the palm rests between the open shank, and is therefore protected from doing injury. The Tyzack anchor is readily fished and got on board by means either of the fish provision on the palm, or the fish shackle fitted to the outer pin in the crown; and is less liable to foul a vessel's fore-grip, from the fact of having only one arm instead of two. This arm is reversible, and so arranged, that, whichever way the anchor falls, it finds itself at once in a position to bite. A further advantage claimed for the Tyzack anchor is, that it can be readily taken to pieces.

Swinburn's portable anchor is another modern invention adapted for general purposes, and especially to be carried as a spare anchor. It is simple in construction, the shank being a square bar, in each end of which are two holes through which bolts are passed, securing the arms, stock, and collars. The two holes at each end are parallel to each other, but at right angles to those at the opposite end. The two pairs of arms are exactly alike, so that one pair can be used as a stock. There are two collars and two shackles, the shackle at the crown of the anchor serving to hook the fish to it. These collars support the bolts, securing arms, and stock. All these parts being exactly alike are interchangeable, so that the anchor can be put together or taken to pieces with great readiness, and can be easily stowed away, either together or separate, in places not available for other anchors. There is no welding, and by using a pair of arms as a stock, great holding power is gained as well as greater certainty of acting.

Among other English anchors, now more or less superseded by some of those already referred to, may be mentioned Trotman's anchor, whose peculiarities are as follow:—The arm has sufficient length and curve to deepen and set the palm at such an angle as to ensure its biting or penetrating the hardest bottom; the area and surface of the palm are greatly increased, offering a proportionate resistance in soft ground; the toggle or projection at the back of the arms is rendered more effective by its form and position; and the mode in which the upper arm rests on the shank, increases both the strength and the penetrating power. This form of anchor possessed some good qualities as to holding, stowage, tripping, and fouling, in comparison with the ordinary Admiralty anchor, at the time it was introduced; but it will be chiefly remarkable as forming a subject of contention between the inventor and the Lords of the Admiralty, and the steadfast refusal of successive Boards of Admiralty to admit the Trotman anchor into the Royal Navy, except in a few isolated instances.

Rodgers's anchor, so well known to nautical men, was made on a principle which afforded great strength without increasing the weight. It was called a "hollow-shanked" anchor, obviously a misnomer, since the shank was not strictly hollow, for it had a wooden core, which was bound to the iron of the shank by iron hoops.

Porter's anchor may be said to have formed the basis of construction, which some more recent inventors have modified. In this anchor the arms are pivoted to the stock, instead of being rigidly fixed; and there is a projecting piece, called the "toggle," on the convex part of each arm. These two adjustments have a remarkable effect on the action of the anchor. Among other advantages, it is said there is less chance of fouling, by the cable passing over the exposed fluke of the anchor, when the vessel is swinging in a tide-way; there is less danger of injury from the upper peak; the lower peak bites quickly into the most stubborn ground; the anchor cannot lodge on its stock-end; while it is stronger in the arm, and may be very conveniently stowed away on shipboard.

Stuard's anchor is a singled-armed anchor, having a very short shank made in one piece with the arm, the pile being bent, but not welded. The stock is a wrought-iron bar with knobs on the end, which cant the anchor, so that its fluke penetrates the ground as it is dragged along. One hole in the shank is for attachment of the cable, and a shackle at the crown is for the buoy rope.

A few years ago anchor making was conducted on a considerable scale at the Government Dockyards, but the larger portion of the supply for Her Majesty's Navy, and also for our mercantile marine, is now obtained by contract from private firms; and some of the principal foreign governments send their orders for anchors and cables to England to be manufactured by our skilled anchor-smiths of "best Staffordshire" iron. Indeed, anchors require to be made of the very best and toughest wrought iron. A large proportion of the iron produced in South Staffordshire is used for local manufacturing purposes; and for chains, cables, and anchors alone, it is estimated that nearly 70,000 tons of iron ore are annually consumed, between two and three thousand persons being employed in this department of industry in what is called the "Black Country."

In anchor making the preliminary process is the "piling" the scrap iron, which, by preference, is used for the purpose. The piles are about 1½ cwt. weight each, and after each separate pile has been melted in a furnace, it is placed under a powerful steam hammer and hammered into slabs. These slabs are afterwards placed together—fifty or one hundred of them, according to the size of the anchor to be produced—and the whole subjected to the forging process under a powerful drop hammer. The smaller and more difficult portions are shaped and rounded off, and the whole anchor finished up by hand. This portion of the work, especially in case of a large anchor, is one of the most arduous labours which can fall to the lot of an anchor-smith. The workmen are unable to stand the intense heat from the huge mass of red-hot metal and wield the ponderous sledge-hammers employed but for a very short space of time: each, therefore, strikes his blow and falls back to make room for another, who in turn retires to give place again to his predecessor, and so on until the iron becomes too cool for further hammering. This task requires a considerable share of strength, activity, and endurance on the part of the forgers, who are not only compelled to strike while the iron is hot, but have to put in as many and as heavy blows with the hammer as they possibly can in the time. These repeated blows are given with such regularity and precision that the sound reverberates quite musically—something like the peal of bells, and to a distant ear, listening to them for the first time, has rather a pretty effect.

There are half a dozen firms engaged in the anchor trade in South Staffordshire and East Worcestershire, namely, Noah Hingley and Sons, Netherton; Joseph Wright and Co., Limited, Tipton; Parkes and Ross, Tipton; T. P. Jones, Cradley; Homer and Mountford, Cradley; and J. W. Aston, Cradley. These makers frequently execute large orders for foreign countries, especially the Australian Colonies, India, and Japan.

A few anchors are made at Newcastle-on-Tyne and Glasgow.

The manufacture of chains and cables has for many years been carried on in the neighbourhood of Birmingham, this special industry taking precedence, chronologically, of the anchor trade. Chain making is confined chiefly to the parishes of Tipton and West Bromwich, with Rowley Regis, and the mineral district south-west of Dudley. Up to within the last half-century, the bulk of the chains manufactured were produced in the several smithies or forges of the workpeople at their own homes; and in the lighter branches of chain making, as in nail making, more or less female labour was employed. With the advent of capital and enterprise, however, the manufacture has since been largely developed, and the business is now for the most part carried on on the factory system, without female labour, much to the advantage of the operatives, and with more uniform results as regards the quality of work. Much of the common chain of commerce is still made by outworkers, to whom iron is given out in small quantities by the manufacturer to be worked up; but, as it often happens that the chain forger and his family have taken out iron from several masters at the same time, there is no dependence upon the quality of the iron returned to the warehouse in the shape of finished chain. Some manufacturers have all best chain made in their own works, under such safeguards as to enable them to warrant its quality.

The first step in chain making is the cutting up of the iron to form the links. This is done by the aid of powerful shears, into which the bar or rod is fed to a certain length, regulated by a stop, when the iron is cut off by the jaws of the machine and falls to the floor beneath. The iron is sheared cold, and the power of the shears is such, that it will clean cut any sized bar up to 3½ inches in diameter. The straight lengths then go to the forging shops to be converted into links. In the case of heavy cables the straight pieces of iron are passed from the shears to the furnace, where they are made red-hot, and while in this ductile state, they are severally bent by a bending machine into link shape ready for the welder's forge.

One noteworthy feature in chain-cable making is that all the forging is done by "hammer and hand," no machinery yet invented being capable of perfect welding by pressure. All forgemen admit, that it is only by rapid impact frequently repeated that a sound weld can be made, and this is supplied only by manual labour.

The handicraftsman who makes one kind of chain is generally unable to produce any other, i. e. the workman, as a rule, fixes upon a certain sized chain, keeps that in his eye, and he must make that size only if he is to work to advantage. The cable shops do not differ from the chain shops, except in the size of the forges and the weight of the hammers and other tools employed in welding the links. These links are, some of them, of enormous size, the iron being from 2 to 3 inches in diameter. The welding is accomplished with marvellous rapidity, the blows being given with hammers wielded by the forger and his striker alternately. While the link is still hot, and before receiving the final tap with the hammer, a stud is inserted, which has the effect of preventing the link from collapsing on pressure being applied to the cable in actual use. When a length of cable is allowed to cool, it is thoroughly tested.

In some of the works automatic labour-saving machinery and appliances are employed. At the Neptune Works of Messrs. Wright and Co., Tipton, I saw in operation a self-acting apparatus which rapidly fetched, carried, and finally disposed of the finished chain in the most remarkable manner. This machine would pull away a length of made chain from the workmen in any part of the works as soon as finished, and quietly drop it alongside the proving machine; again, as soon as the requisite test has been applied, the chain is picked up by the same apparatus, wound around a drum, and dropped from thence on to the weighing machine; and after being weighed, it is once more taken in tow by the apparatus, which deposits it in the tar tank, where it is blacked, and finally drops the chain complete into a canal boat alongside. A girl simply " minds " the machine, but beyond that no manual labour is necessary.

About thirteen years ago an Act of Parliament was passed, the preamble of which affirmed that " for the better security of lives and property afloat in sea-going ships, it is expedient to make provision for the proper testing of chain cables and anchors." Under this enactment, which has since been amended in some particulars, testing-houses have been established in different parts of the United Kingdom. There are at the present time seven of these establishments in operation, namely, Netherton, Tipton, Chester, Newcastle-on-Tyne, Sunderland, Glasgow, and Cardiff—all licensed by the Board of Trade. The officers are all appointed and controlled exclusively by the committee of Lloyd's, and the testing done by them is only for the requirements of the British Mercantile Marine. All the testing of anchors and chain cables for the Royal Navy is done at the Government Dockyards. Under these Acts all chains and anchors supplied to our merchant ships must be definitely proved at one of the recognized testing-houses. The supplies for foreign ships are exempt from this compulsory process, but of late years foreign buyers of ground tackle have become more alive to the quality *after* proof, and the practice of having the work tested is becoming more general.

The tensile strain on chain cables is as follows: Stud-link chain, 630 lbs. to the circular eighth of an inch; short-link cables, 420 lbs. to the circular eighth of an inch.

For anchors the tensile strain is: for a 5 cwt. anchor, 7⅜ tons; 10 cwt., 12 tons; 20 cwt., 20¾ tons.

The rules as to testing are very strict. Each 15 fathoms of chain cable has a sample of three links taken out. If that fails to stand the required strain, another sample is tried; and if that also fails, the length of chain is rejected. Should, however, the first or second sample stand the test, the 15 fathom length is submitted to a tensile strain, and if after being examined, it is found correct, the chain is stamped with the proof-mark, then blacked and passed, ready for use or shipment.

A similar process is gone through with regard to anchors, which undergo tests varying in intensity according to weight. While testing, the deflection of the anchor is tried, when, if the permanent deflection is found to be too great, the anchor is not passed. If, on the contrary, it stand the test, it is carefully examined, stamped, and passed with approval. The testing in all cases is by hydraulic power and dead-weight machine. The apparatus employed is rather complicated, and specially constructed for recording the most accurate results.

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